DEVELOPMENT OF REPAIR PROCESSES AND SOURCES FOR C/KC-135 AIRCRAFT WINDOWS/WINDSHIELDS

Battelle
. . . Putting Technology To Work

RICHARD J. OLSON

BATTELLE
505 KING AVENUE
COLUMBUS, OH 43201

SEPTEMBER 1994

TECHNICAL REPORT FOR 09/91 - 01/94
C/KC-135 FINAL REPORT
CONTRACT NUMBER FO9603-90-D-2217-SD02

DISTRIBUTION AUTHORIZATION: APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

PREPARED FOR
OKLAHOMA CITY AIR LOGISTICS CENTER
TINKER AFB, OK 73145

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1994	Technical, C/KC-135 Final Report, 9/01/91 - 01/31/94

4. TITLE AND SUBTITLE
Development of Repair Processes and Sources for C/KC-135 Aircraft Windows/Windshields

5. FUNDING NUMBERS

6. AUTHOR(S)
Richard J. Olson

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Battelle
505 King Avenue
Columbus, Ohio 43201-2693

8. PERFORMING ORGANIZATION REPORT NUMBER
Contract FO9603-90-D-2217-SD02

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Oklahoma City Air Force Logistics Center
OC-ALC/TIETR
3001 Staff Drive, Suite 2AF66A
Tinker AFB, OK 73145-3040

Technology Transition Office
ASC/SMT
2690 C, Suite 5
Wright-Patterson AFB, OH 45433-7412

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
VEP87CR52R1

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 Words)

The U.S. Air Force has historically rejected the notion of using repaired windows/windshields (W/WS). With increasing pressure to reduce fleet operating costs and based on the favorable experience that commercial fleets have had, interest in using repaired W/WS is receiving greater attention. To ensure that repaired W/WS are safe and that they provide similar benefits for the Air Force, a program of evaluation and testing was undertaken to compare new and repaired C/KC-135 W/WS. Optical and electrical properties, pressure integrity, and bird impact resistance of repaired and new W/WS have been evaluated. The bird impact test results are the first data that the Air Force has collected for C/KC-135 W/WS. The functional testing indicated that repaired W/WS are not equal to new W/WS; the new W/WS outperform the repaired W/WS. In terms of removal for cause criteria and absolute performance requirements, however, the repaired W/WS appear to be "good enough." Concerning costs, the direct costs for repair of the W/WS in this program ranged from 65-75% of new W/WS cost, suggesting that money can be saved.

14. SUBJECT TERMS
Aircraft Transparencies, C/KC-135, Windows/Windshields, Repairs, Pressure Cycle Testing, Falling Ball Impact Testing, Bird Impact Testing, Repaired Window/Windshield Costs Analysis

15. NUMBER OF PAGES
264

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

This page intentionally left blank.

TABLE OF CONTENTS

REPORT DOCUMENTATION PAGE . . . iii

TABLE OF CONTENTS . . . v
LIST OF TABLES . . . vi
LIST OF FIGURES . . . vii
SUMMARY . . . x
PREFACE . . . xii

1.0 INTRODUCTION . . . 1
- 1.1 Background . . . 1
- 1.2 Objective . . . 1
- 1.3 Approach . . . 1
- 1.4 Report Contents . . . 2

2.0 PROTOTYPE SELECTION . . . 3
- 2.1 C/KC-135 W/WS . . . 3
- 2.2 Program Prototypes . . . 5
- 2.3 C/KC-135 #1 and #4 W/WS . . . 5

3.0 W/WS REPAIRS . . . 6
- 3.1 Aircraft W/WS Damage . . . 6
- 3.2 Repair Vendors . . . 8
  - 3.2.1 NORDAM Transparency Division . . . 8
  - 3.2.2 Perkins Aircraft Services, Inc. . . . 8
  - 3.2.3 The Glass Doctor . . . 9
- 3.3 Repair Details . . . 9

4.0 PERFORMANCE TESTING . . . 10
- 4.1 Test Philosophy . . . 10
- 4.2 Quality Assurance . . . 12
- 4.3 General Inspection . . . 12
  - 4.3.1 Test Procedures . . . 12
    - 4.3.1.1 General Visual Examination . . . 13
    - 4.3.1.2 W/WS Dimensional Measurements . . . 14
    - 4.3.1.3 Basic Electrical Measurements . . . 14
    - 4.3.1.4 Heater Operation Tests . . . 14
    - 4.3.1.5 Optical Performance . . . 15
  - 4.3.2 General Inspection Test Results . . . 16
- 4.4 Pressure Integrity . . . 17
  - 4.4.1 Test Procedures . . . 17
    - 4.4.1.1 Proof Pressure Test . . . 17
    - 4.4.1.2 Cyclic Durability Test . . . 17

A-1

TABLE OF CONTENTS
(Continued)

4.4.2 Test Facility . . . 18
4.4.3 Test Results . . . 19
4.5 Residual Strength Assessment . . . 20
4.5.1 Test Procedures . . . 20
4.5.2 Test Facility . . . 20
4.5.3 Test Results . . . 20
4.6 Bird Impact Testing . . . 21
4.6.1 Test Procedures . . . 21
4.6.2 Test Facility . . . 21
4.6.3 Test Results . . . 22
4.7 Performance Testing Summary . . . 23

5.0 COST ANALYSIS . . . 24
5.1 Repair Costs . . . 24
5.2 Costs of New W/WS . . . 24
5.3 Cost Comparison . . . 24

6.0 CONCLUSIONS, RECOMMENDATIONS, and DISCUSSION . . . 25
6.1 Conclusions . . . 25
6.2 Recommendations . . . 27
6.3 Discussion . . . 29

7.0 REFERENCES . . . 31

APPENDIX A. REPAIR VENDOR AIR AGENCY CERTIFICATES . . . A-1
APPENDIX B. GENERAL INSPECTION DATA SHEETS . . . B-1
APPENDIX C. BIRD IMPACT DATA SHEETS . . . C-1

LIST OF TABLES

Table 2.1 C/KC-135 W/WS Part Numbers . . . 33
Table 2.2 C/KC-135 Program W/WS . . . 33
Table 2.3 C/KC-135 #1 and #4 W/WS Dimensions . . . 36
Table 3.1 C/KC-135 Repaired and Not Repaired #1 W/WS in the Test Program . . . 37
Table 3.2 C/KC-135 Repaired and Not Repaired #4 W/WS in the Test Program . . . 38
Table 4.1 C/KC-135 #1 W/WS General Examination and Dimensional Measurements Test Results . . . 39
Table 4.2 C/KC-135 #4 W/WS General Examination and Dimensional Measurements Test Results . . . 41
Table 4.3 C/KC-135 #1 W/WS Basic Electrical Measurements Test Results . . . 43

LIST OF TABLES
(Continued)

Table 4.4 C/KC-135 #4 W/WS Basic Electrical Measurements Test Results 44
Table 4.5 C/KC-135 #1 W/WS Heater Operation Test Results 45
Table 4.6 C/KC-135 #4 W/WS Heater Operation Test Results 46
Table 4.7 C/KC-135 #1 W/WS Optical Performance Test Results 47
Table 4.8 C/KC-135 #4 W/WS Optical Performance Test Results 48
Table 4.9 C/KC-135 #1 W/WS Pressure Integrity Test Results 49
Table 4.10 C/KC-135 #4 W/WS Pressure Integrity Test Results 50
Table 4.11 C/KC-135 #1 W/WS Residual Strength Ball Drop Test Results 51
Table 4.12 C/KC-135 #4 W/WS Residual Strength Ball Drop Test Results 52
Table 4.13 C/KC-135 #1 W/WS Bird Impact Test Results 53
Table 4.14 C/KC-135 #4 W/WS Bird Impact Test Results 54
Table 4.15 C/KC-135 W/WS General Inspection Summary 55
Table 4.16 C/KC-135 W/WS Pressure Integrity Test Summary 56
Table 4.17 C/KC-135 W/WS Ball Drop Residual Strength Test Summary 56
Table 4.18 C/KC-135 W/WS Bird Impact Test Summary 57
Table 4.19 C/KC-135 #1 W/WS Mounting Edge Measurements and Bird Impact Test Results 58
Table 5.1 Initial C/KC-135 W/WS Repair Estimates 59
Table 5.2 C/KC-135 #1 W/WS Actual Repair Costs 60
Table 5.3 C/KC-135 #4 W/WS Actual Repair Costs 61
Table 5.4 Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS 62
Table 5.5 C/KC-135 New W/WS Costs 65
Table 5.6 Repair Cost Comparison Data for C/KC-135 W/WS 65

LIST OF FIGURES

Figure 2.1 C/KC-135 W/WS Identification 66
Figure 2.2 C/KC-135 W/WS Construction 67
Figure 2.3 W/WS Construction Showing Location of Slip Planes 68
Figure 2.4 C/KC-135 #1 W/WS Cross-Section 69
Figure 2.5 C/KC-135 #4 W/WS Cross-Section 70
Figure 3.1 The Glass Doctor Patented Technique for Repair of Conical Cracks in Laminated Glass, U.S. Patent # 3,841,932 71
Figure 3.2 The Glass Doctor Patented Technique for Repair of Delaminations, U.S. Patent # 4,780,162 72
Figure 4.1 C/KC-135 #1 W/WS Thermal Images From the Heater Test 73
Figure 4.2 C/KC-135 #4 W/WS Thermal Images From the Heater Test 74
Figure 4.3 Worst Optical Distortion Found in Any C/KC-135 #1 W/WS (S/N 83-H-11-7-432) 75

LIST OF FIGURES
(Continued)

Figure 4.4 Worst Optical Distortion Found in Any C/KC-135 #4 W/WS (S/N 87-H-04-20-130) 76
Figure 4.5 Pressure Integrity Testing Facility 77
Figure 4.6 C/KC-135 #1 W/WS Pressure Integrity Mounting Frame 78
Figure 4.7 C/KC-135 #4 W/WS Pressure Integrity Mounting Frame 79
Figure 4.8 C/KC-135 W/WS Mounting Details 80
Figure 4.9 Typical C/KC-135 #1 W/WS Pressure Integrity Test Set Up 81
Figure 4.10 Typical C/KC-135 #4 W/WS Pressure Integrity Test Set Up 82
Figure 4.11 Worst Delamination Observed in a C/KC-135 #1 W/WS From Pressure Cycling (Repaired W/WS, S/N 82-H-09-06-537) 83
Figure 4.12 Worst Delamination Observed in a C/KC-135 #4 W/WS From Pressure Cycling (Repaired W/WS, S/N 5-H-12-16-47) 84
Figure 4.13 Residual Strength Falling Ball Test 85
Figure 4.14 #1 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Consequences of Two Ball Drops (New W/WS, S/N 86-H-10-06-062)86
Figure 4.15 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Outboard View (S/N 82-H-9-6-537) 87
Figure 4.16 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Inboard View (S/N 82-H-9-6-537) 88
Figure 4.17 #4 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Test Result (New W/WS, S/N 92-093-HO-388) 89
Figure 4.18 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Outboard View (S/N 5-H-12-16-47) 90
Figure 4.19 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Inboard View (S/N 5-H-12-16-47) 91
Figure 4.20 C/KC-135 #1 W/WS Bird Impact Mounting Frame 92
Figure 4.21 C/KC-135 #4 W/WS Bird Impact Mounting Frame 93
Figure 4.22 C/KC-135 #1 W/WS Mounting Hardware Details 94
Figure 4.23 Schematic of the PPG Bird Cannon 95
Figure 4.24 Support Frame Used for Bird Impact Testing for C/KC-135 W/WS . . . 96
Figure 4.25 Typical Pre-Test View of C/KC-135 #1 W/WS (Copilot) Prior to Bird Impact Testing 97
Figure 4.26 Typical Pre-Test View of C/KC-135 #4 W/WS (Pilot) Prior to Bird Impact Testing 98
Figure 4.27 Bird Impact Test Set Up Showing Impact Velocity Timing Trap (Right) and Front High Speed Film Camera Equipment (Center) 99
Figure 4.28 Bird Impact Spall Sheet Viewed From Behind a C/KC-135 #1 W/WS 100

LIST OF FIGURES
(Continued)

Figure 4.29 C/KC-135 #1 W/WS Showing No Damage From a 4-Pound Bird Impact at 250.8 Knots (Repaired W/WS, S/N 89-286-HO-697) 101
Figure 4.30 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Front View (New W/WS, S/N 86-H-10-06-007) 102
Figure 4.31 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Rear View (New W/WS, S/N 86-H-10-06-007) . 103
Figure 4.32 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Front View (Repaired W/WS, S/N 82-H-10-18-107) 104
Figure 4.33 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Rear View (Repaired W/WS, S/N 82-H-10-18-107) 105
Figure 4.34 Spall Sheet Condition From a 4-Pound Bird Impact at 249.4 Knots on a C/KC-135 #1 W/WS With All Glass Plies Failed (Repaired W/WS, S/N 82-H-10-18-107) 106
Figure 4.35 C/KC-135 #4 W/WS Showing No Damage From a 4-Pound Bird Impact at 248.7 Knots (Not Repaired W/WS, S/N 4-H-10-9-69) 107
Figure 4.36 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Front View (Repaired W/WS, S/N B75-1149) . . 108
Figure 4.37 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Rear View (Repaired W/WS, S/N B75-1149) . . 109
Figure 4.38 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Front View (Not Repaired W/WS, S/N 7-H-2-4-35) 110
Figure 4.39 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Rear View (Not Repaired W/WS, S/N 7-H-2-4-35) 111
Figure 4.40 Spall Sheet and W/WS Condition From a Catastrophic 4-Pound Bird Impact at 250.8 Knots on a C/KC-135 #4 W/WS (Not Repaired W/WS, S/N 7-H-2-4-35) 112
Figure 6.1 Heat Strengthened Glass Residual Stresses 113

SUMMARY

The Air Force, in trying to reduce fleet maintenance costs, is considering using repaired windows/windshields (W/WS). Based on reported cost savings and favorable experience that commercial fleets have had with repaired W/WS, the use of repaired W/WS seems very attractive. Before adopting an operating policy to use repaired W/WS, however, the Air Force decided that structural performance testing of repaired W/WS and a cost analysis were required.

The approach followed for evaluating whether the use of repaired W/WS is justified was to procure some used C/KC-135 W/WS, make repairs on them, and then subject the repaired W/WS to a series of tests to determine the difference in performance when compared with new W/WS. The cost to make the repairs provides the data for the cost benefit analysis. The test results provide the data for an evaluation of fitness for purpose of repaired W/WS.

The testing conducted for this program represents the first full-range, systematic testing of the structural integrity of repaired W/WS for transport-type aircraft. Optical and electrical properties, pressure integrity, and bird impact resistance have been evaluated. In addition, the bird impact test results are the first data that the Air Force has collected for C/KC-135 W/WS.

The test results indicate that repaired W/WS have been restored to a condition better than the prevailing C/KC-135 Technical Order replacement criteria, but they do not perform as well as new W/WS. Many of the repaired W/WS still contain defects that would not pass an OEM quality assurance inspection. Some delamination occurred in a few of the repaired W/WS during pressure cycling, but it was not severe. The residual strength of the pressure cycled W/WS tends to suggest that the repaired W/WS are not quite as good as new W/WS. The bird impact test results are quite clear - new W/WS outperform either repaired or unrepaired W/WS. At the 250 knot impact velocity used in this program, all of the new and repaired #1 and #4 W/WS do, however, meet the no bird penetration requirement, while two of the repaired #1 W/WS technically failed the no spall criterion. From a practical viewpoint, the spall was very modest. One W/WS that was not repaired because of an out of specification heater resistance, failed catastrophically in the bird impact test.

Although repaired W/WS do not perform as well as new W/WS, they were, in fact, restored to a condition better than the prevailing C/KC-135 Technical Order W/WS replacement criteria. On the basis of the fact that they would not be removed from service if found on an aircraft, and the fact that they prevented bird penetration, repaired W/WS appear to be "good enough," at least at a 250 knot bird impact velocity.

The cost analysis indicates that savings may be realized. For this program, the cost of making the repairs was 75-percent of the new W/WS purchase price for #1 W/WS and 65-percent for the #4 W/WS. Considering all five of the C/KC-135 W/WS types and the full

range of estimates, quotes, and actual costs, repairing a C/KC-135 W/WS might cost as little as 41-percent of a new W/WS, but it could also cost as much as 132-percent.

The cost savings are only the direct repair costs. To this must be added the direct cost of transportation and the indirect costs of procuring the service (contracting), administrating it (accounts payable, records management, etc.) and operating it (storage, shipping and handling, outgoing/incoming inspection, etc.). Offsetting these items are a reduced burden, both economic and environmental, from lower landfill costs for W/WS that are taken out of service. These factors will certainly impact the economics and to ignore them would be a false economy. The Air Force should do a complete cost/benefit analysis to satisfy themselves that there is a true economic advantage to using repaired W/WS.

A significant peripheral finding from this study is that a blanket 10-year transport-type aircraft W/WS replacement policy cannot be justified, if W/WS manufacture date is used as the indicator of age. The new W/WS used in this program were manufactured in 1986, and they showed no evidence of degradation due to being in storage for 7 years. To remove and replace these W/WS in 1996, solely on the basis of age, would be wasting operating and maintenance dollars. A better scheme for tracking service history and a service-history-based replacement criterion must be devised for a blanket W/WS replacement policy.

Recommendations that can be made as a result of the work performed on this program are contingent upon the Air Force making a decision, based on the available data, that the performance of repaired W/WS is acceptable. If, in the opinion of the Air Force, the performance of repaired W/WS is deemed "good enough," recommendations are made for approved W/WS repair vendors and repair processes. Recommendations for operating a W/WS repair program are also made.

PREFACE

The work reported herein was performed by Battelle, Columbus, Ohio, under Air Force Contract FO9603-90-D-2217-SD02, "Development of Repair Processes and Sources for C/KC-135 and B-52 Aircraft Windows/Windshields." The program was directed by the Oklahoma City Air Logistics Center (OC-ALC) at Tinker Air Force Base. Air Force administrative direction was provided by Ms. Cindy Cooper, OC-ALC/LADCB. Air Force technical direction was provided by Mr. Robert Koger, OC-ALC/TIETR.

The work was performed during the period of September 1991 to January 1994. The technical program at Battelle was directed by Mr. Richard Olson of Battelle's Engineering Mechanics Department and Mr. Dennis Miller of Battelle's Polymer Center. The author wishes to acknowledge Mr. Herb Goodrich of PPG Industries, Inc. Aircraft Products Division in Huntsville, Alabama for coordinating and conducting the W/WS testing, and Mr. Ryan Rice at Battelle for preparation of the manuscript.

1.0 INTRODUCTION

1.1 Background

Several facilities exist for repairing aircraft windows/windshields (W/WS), and with U.S. Federal Aviation Authority (FAA) approval, many commercial airlines are currently utilizing these services. The cost of repairing a W/WS is substantially less than the purchase price of a new W/WS for commercial fleets, so the incentive for them to use repaired W/WS is large. The favorable experience that the commercial fleet has had with repaired W/WS suggests that they will continue to use repaired W/WS in the foreseeable future.

The U.S. Air Force has historically rejected the notion of using repaired W/WS. With decreasing Congressional funding for the military, measures to reduce fleet operating costs are receiving greater scrutiny. Based on the experience that the commercial fleet has had with repaired W/WS, the issue of using repaired W/WS on military aircraft is now being systematically considered. To ensure that repaired W/WS are safe and that they provide a similar cost savings benefit to the Air Force, a program of thorough evaluation and testing was required.

In September 1991, the Air Force contracted with Battelle to investigate the consequences and impact of using repaired W/WS. The program was to evaluate feasibility by testing the functional performance of repaired W/WS and by performing an economic analysis. Adequate functional performance and a favorable economic analysis would then provide the justification for a recommendation to use repaired W/WS.

The maintainability of Air Force fleet aircraft is an on-going concern because many of the aircraft in the current inventory are projected to have significant roles for many more years (10 to 20 years). By decreasing the lead time and procurement costs for W/WS, the maintainability of the fleet is enhanced. Furthermore, by gaining more control over the spare parts inventory, fewer new parts will be required and the costs of the W/WS program will be reduced.

1.2 Objective

The objective of this program was to provide a rationale for either accepting or rejecting the use of repaired W/WS in Air Force fleet aircraft.

1.3 Approach

The approach followed for evaluating whether use of repaired W/WS is a viable option for the Air Force was to procure some used W/WS, make prototypical repairs on them, and then subject the repaired W/WS to a battery of tests to see if there is any difference in performance when compared with new W/WS. Making prototypical repairs provides

baseline data for repair costs. The battery of tests provides an evaluation of fitness for purpose of the repaired W/WS.

The W/WS selected for evaluation in this program were from C/KC-135 aircraft. These W/WS are of typical laminated glass and plastic construction and include integral heaters. Repairs considered in this program included surface damage, delamination, electrical heater problems, broken layers, and seal/mounting problems. Repairs were subcontracted to commercial fleet W/WS repair stations with instructions to return repairable W/WS to Original Equipment Manufacturer (OEM) specifications per the approved processes in the repair vendor's FAA W/WS Air Agency Certificates. The direct costs for performing the repairs on the test prototypes forms the foundation of the economic analysis.

The approach to evaluating the functional performance of the repaired W/WS involved a rigorous set of tests designed to determine if the repair processes have degraded the W/WS when compared with new W/WS. Both repaired and new W/WS were subjected to pressure, impact, optical, and heater operation tests, similar in spirit to W/WS qualification tests. Provided that the repaired and new W/WS perform the same, the use of repaired W/WS can, at least on a performance basis, be justified.

1.4 Report Contents

In the sections that follow, the results of this 2½-year study are presented. The report begins with a discussion of the selection of repair candidate prototypes for the program and ends with recommendations for the Air Force on implementing a W/WS repair program. Topics presented include:

- C/KC-135 W/WS construction details
- Selection and condition of the W/WS repaired in this program
- A generic discussion of glass-laminate aircraft W/WS repairs, identification of the repair vendors that were involved with this program, and details of the actual repairs made to the W/WS
- Repaired W/WS performance evaluation, including test procedures, pass/fail criteria, and test results
- A cost analysis
- Conclusions and recommendations.

2.0 PROTOTYPE SELECTION

The C/KC-135 aircraft was selected as the prototype for evaluating the feasibility of using repaired W/WS because the number of aircraft in the fleet is fairly high, the C/KC-135 is projected to be in service for many more years, and because the repair vendors have direct experience repairing the essentially equivalent Boeing 707 W/WS. The C/KC-135 has 10 cockpit W/WS identified in Figure 2.1, 5 on the pilot side and 5 on the copilot side. The set of five W/WS on the copilot side are a mirror image of the pilot side W/WS. W/WS #1 is the forward W/WS, #2 and #3 are side W/WS, and #4 and #5 are eyebrow W/WS. All of the W/WS except #2 are fixed in position. W/WS #2 opens to provide ventilation and ground communication by sliding aft on a track. Table 2.1 lists the current part numbers for the C/KC-135 W/WS.

2.1 C/KC-135 W/WS

Figure 2.2 shows the general construction of the C/KC-135 W/WS. The C/KC-135 W/WS have a three-part glass and vinyl laminate construction. The inner layer is thick, heat-strengthened plate glass designed to withstand cabin pressure forces. A transparent, plasticized, polyvinyl butyral core layer acts as the "fail-safe" load carrying member and prevents shattering in the event of inner ply failure. The outer ply is a relatively thin layer of heat-strengthened glass with no structural significance, but it provides rigidity and a scratch-resistant surface. A phenolic or masonite filler strip, located around the edge of the W/WS, and a metal filler strip embedded in the vinyl provide the means to attach the W/WS to the airframe. Vinyl or vinyl and rubber bumpers protect the sides of the outer ply.

The structural integrity design of C/KC-135 cockpit W/WS is based on two requirements: "fail-safe" pressure integrity and bird impact resistance. The "fail-safe" pressure integrity is founded on two redundant systems, an inner glass ply that can sustain the full rated cabin pressure in the absence of all other layers, and a polymeric core ply that can maintain pressure integrity if the inner and outer glass plies are cracked. The bird impact structural integrity of W/WS is either characterized as "bird bagging" or "bird bounce." Bird bagging W/WS, typically two glass layers with a polymeric core ply, stop bird penetration by large ductile deformation of the core ply, i.e., "bagging" the bird. Bird bounce W/WS are typically multilaminates and cause the bird to "bounce" off the W/WS. The C/KC-135 W/WS main cockpit W/WS are "bird bagging" W/WS.

The glass used in C/KC-135 W/WS is heat strengthened to provide resistance to cracking. The glass is heated to near the softening point and then quenched to produce compressive residual stresses that extend from the outer surface into a depth of about 1/6th of the glass thickness. Below the compressive stress layer lies tensile residual stresses. As long as surface defects do not penetrate into the tensile layer, the glass will exhibit a high resistance to fracture. Once a crack does fully penetrate the tensile layer, the glass will shatter as the tensile stresses are relieved.

The vinyl core, which acts as the "fail-safe" pressure boundary and means for controlling glass fragments in the event of a glass ply failure, is highly plasticized polyvinyl butyral. The vinyl is relatively brittle at low temperatures (-65° F), and unable to absorb much energy per unit volume. At temperatures approaching 130° F, the vinyl becomes very ductile and can absorb a relatively large amount of energy as it is loaded. W/WS heaters, which not only de-fog and de-ice the glass, ensure that the vinyl remains ductile.

An integral part of the C/KC-135 W/WS construction is slip planes or a parting medium at the edges of the glass. A slip plane is located between both the inner glass ply and the vinyl and the outer glass ply and the vinyl as shown in Figure 2.3. The slip planes are thin strips of material at the glass-vinyl interface that keep the glass from bonding to the vinyl. This allows the various plys to move independently at these locations in response to pressure loads and differential thermal expansion. Without the slip planes, the glass at the edges of the W/WS would be prone to fracture because it would exceed its strain limit as it tried to move with the underlying vinyl. The slip planes form a "softer" connection that promotes a more gradual build up of strains in the glass so that it does not exceed its strain capacity. Although the slip planes look similar to delamination, they are not defects but an intentional part of the W/WS design.

The C/KC-135 cockpit W/WS contain heating systems for anti-icing and/or anti-fogging. An electrically conductive film of pyrolytic tin oxide between the outer ply and vinyl core ply is used to heat the #1 and #2 W/WS to reduce ice/frost formation. A similar conductive film between the inner ply and core ply is used on #3, #4, and #5 W/WS for defogging only. The W/WS heating system, so called NESA® coated glass, uses the resistivity of the film to provide the heating. The #1 W/WS also contain fine wires at the W/WS edges between the outer glass ply and vinyl, so-called edge heaters, to correct a heating power deficiency in the corner. The temperature of the #1 and #2 W/WS is controlled with an integral sensor. Externally applied thermal switches control the temperature of #3, #4, and #5 W/WS.

A temperature sensor embedded in the laminate of the #1 W/WS regulates the temperature of the #1 and #2 W/WS when the heater is on. The sensor, a negative temperature coefficient (NTC) thermistor, exhibits increasing resistance with increasing temperature. When wired in an appropriate power amplifier control circuit, as the W/WS and sensor temperature rises, the sensor resistance increases. This causes the control amplifier to shut off current to the W/WS, and hence power dissipated by the heater film, thus reducing the temperature. When the temperature drops below a lower setpoint, the control amplifier turns power back on to the W/WS.

Seals on the W/WS keep cabin pressure in and moisture out. In addition, they act as vibration and shock absorbers and help to compensate for differential thermal expansion. W/WS #3, #4, and #5 utilize a silicone rubber molded-in-place pressure seal that is molded to the W/WS mounting surface. Drawing the W/WS tight to the airframe with its mounting bolts effects the seal. On the #2 W/WS, a bellcrank mechanism presses the W/WS against the airframe when it is closed and latched. The #1 W/WS uses a molded-in-place seal similar the other W/WS, except that a stainless steel Z-channel is sandwiched between a

silicon rubber cushion and a beaded pressure seal. The mounting bolts provide the pressure to hold the W/WS tight against the airframe. All of the C/KC-135 W/WS mount from the inside of the aircraft.

2.2 Program Prototypes

OC-ALC made arrangements to have C/KC-135 W/WS that were removed from fleet aircraft at Tinker AFB shipped to Battelle. Over 100 W/WS were screened to find 75 prototype repair candidates. All five C/KC-135 W/WS types were included in the 75 W/WS population. At the time of their removal, the W/WS were judged not serviceable per the criteria of the applicable C/KC-135 Fuselage Window Tech Order, Section 8 of T.O. 1C-135(K)A-2-2. Indicated reasons for removal from service included: failed heaters, bubbles, scratches, separation, leaks, old, discolored, and corrosion.

The service history of the prototype repair candidates is not known because: 1) very few of the W/WS had airframe numbers, 2) W/WS are not tracked by serial number, and 3) planes are moved from location to location as a part of normal squadron rotation. In most instances, the date of removal from service was not noted. The installation date is not known for any of the W/WS. All that is known for certain is the year the W/WS was made; the first one or two digits of the serial number indicate the year the W/WS was made - a single digit is a 1970's vintage W/WS.

Table 2.2 lists the type, serial number, and condition of the 75 C/KC-135 repair candidates. W/WS that have serial numbers that begin with numbers were made by PPG, while those that start with letters were made by Libbey-Owens-Ford.

At the outset of the program, the plan was to repair and test some of each of the five different C/KC-135 W/WS. A large number of the repair prototype candidate W/WS, however, were judged not repairable by virtue of out-of-specification or open circuit heaters. In conjunction with OC-ALC, the decision was made to proceed with repairing and testing only #1 and #4 W/WS. Although other repair candidates could have been obtained, it was felt that the program objectives could be adequately met if only two of the five W/WS types were evaluated. The #1 and #4 W/WS were selected because they have construction (and consequently repairs) that is typical of all of the C/KC-135 W/WS, there was enough W/WS in the population to conduct all of the tests in the test matrix, and the #1 and #4 W/WS are the only reasonable bird impact test candidates.

2.3 C/KC-135 #1 and #4 W/WS

Table 2.3 lists the general dimensions for the #1 and #4 W/WS. The #1 W/WS is a flat, nearly rectangular W/WS. The #4 W/WS, on the other hand, is roughly square in the plan view and has curvature (approximately 0.65 inches out of plane across the largest diagonal in the viewing area). The general construction was noted in Section 2.1. Figures 2.4 and 2.5 show detailed cross-sections of the #1 and #4 W/WS.

In general, because the #1 W/WS is flat, it is one of the easiest W/WS to manufacture and repair. Being flat, the optics of #1 W/WS are very good. The curvature on the #4 W/WS tends to result in some degree of optical distortion, and the curvature makes it somewhat more difficult than a #1 to repair, in spite of its small size.

3.0 W/WS REPAIRS

3.1 Aircraft W/WS Damage

The most common failure modes of laminated transparencies are:

- Delamination: separation of vinyl from the glass
- Cracks and chipping: glass breakage due to high stress
- Arcing: unbalanced electrical potential within the conductive coating
- Heater Failure: loss of continuity in the heater or heater sensor circuit
- Impaired Vision: surface scratches, contaminates, or internal defects
- Contamination: air or water leaks caused by defective seals
- Vinyl cracking.

Delamination is separation of the glass surface of the inner or outer ply from the vinyl core ply to which it is bonded. Delamination generally starts at the slip planes and moves inward, although it may occur anywhere in the W/WS. It mainly occurs between the outer ply and the vinyl ply. Delamination does not dramatically reduce the strength of the W/WS, but may interfere with vision or W/WS heating if the delamination occurs at the interface where the heating film is located.

Cracks and chips may occur in either of the glass plys and may be caused by impacts or by high stresses at the edges of the glass. Single cracks in the outer ply are unlikely because the temper in this layer precludes a single crack. After the momentary appearance of a crack in the outer layer, the entire layer shatters very abruptly. Small cracks very near the edges of the W/WS may not be cause for removal, provided the crack is not directed toward the center of the pane. Cracks that adversely affect the functioning of the heater would not be acceptable. Chips may occur internally or externally. Internal chips are caused by the glass-vinyl bond strength exceeding the strength of the glass. External chips are generally caused by impacts. Chips usually have a clamshell shape, are rough, and white powdered glass is often in evidence. Chips are detrimental to the strength of the pane.

W/WS busbar breakdown and faults in the heater film cause arcing. Basically, the insulation breaks down and the heater electrical current short circuits to the airframe. Arcing is evidenced by burned areas around electrical braid and along the busbar.

The failure of the W/WS heater to de-ice or defog satisfactorily is one of the most serious failure modes. Arcing, chips, cracks, or lack of continuity in the heater film that render the heater inoperative are cause for W/WS replacement. Uneven heating or hot spots caused by delamination at the glass-vinyl interface with the heating film or chips may also be a cause for removal.

Satisfactory optical properties of the W/WS are paramount. Foggy or cloudy areas may appear in areas where moisture has penetrated the vinyl and has begun to degrade it. Scratches may occur on both the inner and outer plys that may interfere with visibility. Likewise, delamination may become serious enough to warrant replacement of the W/WS on the basis of reduced visibility. Bubbles may occur in the vinyl core ply in W/WS that have been exposed to elevated temperatures. Bubbles are caused by gas liberated from the vinyl, and grow in size and number with increased temperature or longer exposures. Needless operation of the heaters on the ground is a prime cause of bubbles. Bubbles do not have a large effect on strength of the W/WS, but may become serious enough to impair visibility. Although other failure modes may not be evident, poor optical performance is always a sufficient cause for W/WS replacement.

The bumpers on the edge of the outer glass form a moisture barrier. Degradation of the bumper in the form of cracking or separation from the edge of the outer glass ply can allow moisture and air to get into the slip planes. Moisture can degrade the heater film with consequent initiation of heater failure, arcing, delamination, and contamination.

As a result of aging, cracks may occur in the vinyl. Over time, attack by ultraviolet radiation and high temperatures also causes the vinyl to lose ductility. Eventually, cracks may form around the periphery of the W/WS in proximity to the metal insert as the glass and vinyl try to move relative to one another. Vinyl cracks significantly weaken the structure of the W/WS by putting flaws directly in the load path between the transparency and the airframe for bird impact loads. Per Figures 2.4 and 2.5, only the vinyl extends out to the mounting holes, not the glass. Therefore, if the vinyl is cracked near the metal insert, the W/WS could just "punch out" of the frame into the cabin. The vinyl layer is also the pressure "fail-safe" layer, so vinyl cracks are quite important.

In addition to cracking, the vinyl layer may discolor or darken if it is subjected to temperature in excess of 225 F. Foreign substances in the glass-vinyl interface, either from in-service conditions or introduced as a part of a repair process, may also cause discoloration.

3.2 Repair Vendors

3.2.1 NORDAM Transparency Division

NORDAM Transparency Division is one of the world's largest, privately-held, FAA-approved transparency repair stations. They provide comprehensive overhaul capabilities on glass and acrylic W/WS. Located in Tulsa, Oklahoma, NORDAM has more than 15 years experience in the repair and overhaul of aircraft W/WS.

Repairs that NORDAM is authorized to make include relaminating, surface polishing, and seal rehabilitation. Autoclave curing of delamination, bubbles, voids and interlayer vinyl cracking is done with the same laminating cycles, times and methods utilized in the original manufacture of the W/WS. Polishing includes removal of scratches, chips and pits from the outer glass or acrylic plies. Original optimum optics are restored with the least amount of surface removal, in accordance with strict adherence to OEM manual limits for removal. Seal rehabilitation includes cleaning, repairing, or replacing of seals as required. NORDAM is authorized by the FAA under Air Agency Certificate EZ22812K to make the W/WS repairs. Appendix A has a copy of the certificate.

In addition to their W/WS repair business, NORDAM also manufactures W/WS, cockpit side panels, canopies, cabin windows, wing tip lenses and landing light covers for commercial, regional, military, helicopter, and general aviation aircraft. Products made from stretched and cast acrylic, polycarbonate, and glass are made in either monolithic or laminated configurations.

3.2.2 Perkins Aircraft Services, Inc.

Perkins Aircraft Services, Inc. specializes in the overhaul and repair of both monolithic and laminated aircraft transparencies made of glass or acrylic. Located in Ft. Worth, Texas, Perkins is an FAA-approved repair facility authorized to make in-plant and "on the aircraft" repairs.

A five-step process is used by Perkins to restore damaged W/WS to an FAA-serviceable condition. First, all incoming W/WS are given a thorough inspection to determine whether the W/WS can be repaired. W/WS with out-of-specification electrical systems or that are otherwise judged unrepairable are rejected and returned. The second step of the process is repair of delamination. Using a proprietary autoclave process, the W/WS are heated and pressed to rebond the W/WS layers. Polishing, the third step in the W/WS repair process, is done to remove scratches, chips, and in the case of plastic W/WS, crazing, using automated polishing machines. The fourth step is reassembly. In this step, the transparencies are matched up to their original frames, as applicable, and seals and gaskets are replaced. The final step in Perkins' W/WS repair process is to perform a quality assurance inspection to ensure that all of the necessary repairs have been made and that the

W/WS has been restored to OEM specifications. Perkins holds FAA Air Agency Certificate JKQR257L, see Appendix A, which authorizes them to operate their W/WS repair station.

3.2.3 The Glass Doctor

The Glass Doctor of St. Petersburg, Florida got into the aircraft transparency repair business in 1979 after working in the automobile windshield repair business for 10 years. Starting with cabin window repairs, the business has expanded to also include FAA-approved repair of all cockpit W/WS as well as cabin windows.

The Glass Doctor has developed special techniques for repairing chips, nicks, and delaminations in W/WS. Unlike the other aircraft W/WS repair vendors, The Glass Doctor does not rely solely upon polishing and re-autoclaving of the W/WS to effect the repairs. As described in U.S. patents #3,841,932, #3,914,145, and #4,780,162, The Glass Doctor repairs conical cracks by filling the crack with a polymerizable resin that is vibrated into place by motion of the conical plug, see Figure 3.1. Delamination repairs are made by injecting an adhesive between the delaminated plys per Figure 3.2. Polishing for scratch and distortion removal is also done. Using experience gained from their delamination repair techniques, The Glass Doctor has also developed the unique capability to replace failed W/WS heater sensors and can repair open or arcing busbars. Failed heater sensors are replaced by drilling into the vinyl and potting a new sensor in the hole. Open or arcing busbars are repaired by injecting a conductive adhesive material at the glass-vinyl interface where the busbar defect is located. Although there is some controversy in the aircraft W/WS repair industry associated with the repairs that The Glass Doctor makes, repairs are under warranty for up to 3 years (scratches excluded), and the reported rate of warranty work is very low.

The Glass Doctor operates its W/WS repair station under FAA Air Agency Certificate OX4R430M. A copy of The Glass Doctor's certificate is attached in Appendix A.

3.3 Repair Details

Some of the damage described in Section 3.1 can be repaired. To test the capabilities of the repair vendors to return W/WS to a serviceable condition, contacts at the three repair vendors were established to solicit their interest in participating in this program. Participation in the program was on a paid basis, with the stipulation that the Air Force, through Battelle, had to know something about the repair processes for quality control reasons. In particular, if the repair processes deviate from the processes used in the original manufacture of the W/WS, the Air Force felt that they needed a specification to ensure that they get the same product each time they buy.

In making arrangements for the repairs, Battelle was to sign confidential disclosure agreements with the repair vendors that would prohibit Battelle from disclosing trade secrets and process details. From their advertising literature, it is clear that the W/WS repair

processes used by NORDAM and Perkins are consistent with the original manufacture of the W/WS. The repairs made by The Glass Doctor, on the other hand, because they involve injection of adhesives and resins into the W/WS, are different than the OEM processes.

Terms and conditions for a site visit and repair of a number of W/WS were successfully negotiated only with NORDAM and Perkins. Thus, only NORDAM and Perkins made W/WS repairs for this program.

The set of 75 C/KC-135 W/WS Battelle had to work with was divided, and half sent to NORDAM and half sent to Perkins. Each vendor evaluated the repairability of the W/WS that they were sent and provided an estimate of the repair costs for each W/WS. In conjunction with Battelle engineers, a subset of the 75 W/WS was selected for repair. Perkins repaired 7 #1 W/WS and 2 #4 W/WS. NORDAM repaired 8 #1's and 8 #4's.

Tables 3.1 and 3.2 provide details of the prototype repairs made to the #1 and #4 W/WS that were subsequently tested. To fill out the test matrix, unrepaired W/WS were included in the test program, one #1 and six #4's. The original intent was to have a balanced number of repairs from each vendor and a balance in the types of repairs made. Unfortunately, it did not work out this way, because Perkins got a disproportionately large number of unrepairable W/WS. Because the performance of unrepaired W/WS provides a baseline for as-removed condition, including them in the test matrix was essential.

4.0 PERFORMANCE TESTING

4.1 Test Philosophy

The fitness for purpose of the repaired C/KC-135 W/WS was evaluated using a rigorous test program. In formulating the test program, the plan was to select a set of tests that would assess the critical performance elements of the W/WS: general electrical/optical/mechanical characteristics, pressure integrity, residual strength, and impact resistance. Performing these types of tests at limiting load or operational conditions, failures would be encouraged in repaired W/WS that would not occur in new W/WS unless the repaired W/WS were degraded either by virtue of their age or by virtue of having undergone the repair process.

The test plan was developed as a joint effort between Battelle, OC-ALC, and the Flight Dynamics Laboratory at Wright-Patterson AFB. Because the Air Force does not own the Boeing 707 airframe design on which the C/KC-135 is based, they do not have W/WS drawings and the W/WS design specifications or W/WS vendor qualification test protocols. Consequently, the test plan was developed from the C/KC-135 Tech Orders and the open literature on W/WS testing.[1-10]

In order to assess whether the performance of the repaired W/WS is satisfactory, a standard for comparison must be defined. Obviously, the performance of new W/WS should be the basis for the comparison. Simply stated, the repaired W/WS should perform just like new W/WS. In an ideal situation, information for new W/WS would be available to define the required tests for the repaired W/WS and the existing new W/WS data would form the basis for the comparisons. The information available from Boeing and OC-ALC suggested that data on prior C/KC-135 W/WS testing was sparse or very difficult to retrieve, so the scope of the testing program had to include tests of new W/WS to generate the baseline new W/WS performance data. In addition, because of uncertainty in setting some of the parameter selections for the tests (load levels, primarily), the test program included a methodology phase verification to establish that the new W/WS would pass the tests. Although testing of new W/WS was primarily a response to the lack of readily available new W/WS test data, it does facilitate the process of making the comparisons because both new and repaired W/WS were tested under absolutely identical conditions.

The new W/WS used in this program were supplied by OC-ALC from stock at Tinker AFB. The new #1's were copilot side W/WS. All of the other W/WS in the program were from the pilot side. Copilot side #1 W/WS were used because the stock of these W/WS was higher. The pilot and copilot side W/WS are mirror images of one another, so they should perform identically.

The test program was originally to be conducted at OC-ALC or other Air Force test facilities, with Battelle providing oversight and test data analysis. After the test program was defined, an attempt was made to locate Air Force facilities to perform the prescribed tests. The test plan required facilities for general W/WS optical/electrical/mechanical inspection, pressure and thermal cycling, and bird impact testing. Although portions of the testing could be performed at various Air Force facilities, no single site had all of the capabilities, and in many cases, substantial modifications or upgrades would be required to accommodate the specific needs of this program at sites where portions of the work could be done. In addition, quoted costs at the Air Force facilities were quite high. To fulfill the testing requirement, therefore, an outside vendor, PPG Industries, Inc. Aircraft Products Division was subcontracted to do all of the C/KC-135 W/WS testing.

PPG's Aircraft Products Division, located in Huntsville, Alabama, has been in the aircraft transparency business since 1926 and is an OEM supplier for C/KC-135 W/WS as well as other Boeing 777 series aircraft. The Huntsville plant is America's largest and most modern facility for producing aircraft transparencies. It fabricates W/WS with heat strengthened and chemically tempered glasses, as-cast and stretched acrylics, and polycarbonates for commercial, military, and general aviation aircraft. As a leader in the field of aircraft transparency technology, PPG has built an impressive W/WS qualification testing facility. The facility includes bird impact testing, environmental testing, high strain rate material evaluation, dynamic deflection analysis with high speed photography, dynamic stress analysis with strain gages, and ballistic testing for transparent armor. In performing the tests for this program, PPG used the same test fixtures, test procedures, and QA

requirements in use today to make new OEM W/WS for C/KC-135's. These capabilities at a single site, coupled with their intimate knowledge of the C/KC-135 W/WS and the functionally equivalent Boeing 777 series products, proved valuable to this program.

4.2 Quality Assurance

The testing conducted at PPG was performed in accordance with specifications defined in contract deliverable Data Item A046 to OC-ALC entitled "Final Master Test Plan/Program Test Plan on Development of Repair Processes and Sources for C/KC-135 Aircraft Windows/Windshields." This document was submitted to PPG as "Program Test Plan on Testing of Repaired C/KC-135 Aircraft Windows/Windshields" for preparation of their proposal bid. The corresponding PPG document, "Verification Test Procedure on C/KC-135 Aircraft Repaired Transparencies #1, #4, and #5 Windows, Revision A," was reviewed and approved by Battelle and defined the detailed scope of work.

PPG is an OEM supplier for C/KC-135 W/WS and consequently, they have a vested interest in selling new W/WS. Because using repaired W/WS would reduce sales of new W/WS, PPG could be perceived as having an inherent bias against repaired W/WS which might be reflected in the test results. PPG offered, and Battelle frequently exercised, the option to witness the tests. No indication was ever detected that they were attempting to influence the outcome of the tests. Their work was always done to the highest of professional standards. Fixture fabrication, minor deviations from the prescribed test procedures to accommodate instrumentation problems, etc., were all done with Battelle's concurrence. Suggestions that Battelle made to enhance the value of the test program were willingly implemented. Their final report is presented as a factual record of their observations and does not attempt to bias the conclusions of this report.

All instrumentation used in the conduct of this program was calibrated in accordance with PPG Quality Control procedures which guarantees that all significant instrumentation was in calibration when used and that adequate records are kept to document such calibrations.

4.3 General Inspection

4.3.1 Test Procedures

General electrical/optical/mechanical testing of repaired W/WS was performed to ensure that the W/WS is in specification electrically, that the repair operations have not adversely affected optical qualities, and that the fit and finish is correct. All of the W/WS tested in this program were initially given a thorough 14-item inspection by the PPG Quality Control Department. The inspection included:

1) Locating and recording the customer part number

2) Locating and recording the W/WS serial number

3) General visual inspection

4) Gasket/seal evaluation

5) Thickness measurements at prescribed locations

6) Physical tolerance check

7) Bus-to-bus resistance

8) Sensing element resistance

9) Electrical insulation integrity test

10) Heater operation test

11) Heating film scratch test

12) Luminous transmittance and haze measurement

13) Optical deviation measurement

14) Optical distortion photograph.

With little exception, the indication of which W/WS were new, repaired, or unrepaired was difficult to determine from a superficial visual examination. Only a detailed technical examination, equivalent to an OEM post-production quality control check, was able to uncover differences between the W/WS.

4.3.1.1 General Visual Examination

A visual examination was performed on each W/WS to assess its general condition. During this inspection, the part number and serial number were located and recorded, the W/WS was checked for delaminations and vinyl cracks, and the condition of the seal was evaluated. Criteria for the various aspects of the visual examination were based on PPG experience as an OEM for these W/WS. A rating of accept or reject was employed.

4.3.1.2 W/WS Dimensional Measurements

The repair of delaminations involves re-autoclaving of the W/WS to rebond the vinyl inner layer to the glass. Because the vinyl layer is pressed at an elevated temperature and consequently may flow, the overall thickness of the W/WS may be reduced and the location of power/sensor terminals and bolt holes may shift. To determine if the repair processes cause such changes, some dimensional measurements of the W/WS were made.

To assess the extent of thickness reduction caused by re-autoclaving, total thickness of the W/WS was measured at selected locations. For the #1 W/WS, a 12-point grid was used, while a 2 by 2 grid was used for #4 W/WS. Measurements were made to the nearest 0.001 inch using a micrometer.

The physical tolerance check was made to see if critical dimensions, including proper fit dimensions, location of electrical connections, and bolt hole locations, had been changed by the repairs. Each W/WS was checked using check fixtures used in the original manufacture of these W/WS. An overall dimensional trim check was requested, but the OEM check tool was designed to be used prior to application of the edge coating material. Removal of the edge coating to make the measurements did not seem justified, in light of the fact that part of the repair process entails replacement of the edge coating, so the overall dimensional trim measurement was abandoned. A go-no go rating was used for the check fixture tests that could be made.

4.3.1.3 Basic Electrical Measurements

Electrical resistance measurements were made using the standard electrical resistance measurement function on Fluke digital multimeters to determine if the heaters and sensors were within acceptable tolerances. Both bus-to-bus resistance and sensor resistance (#1 W/WS only) were measured. From the Boeing overhaul manual, the bus-to-bus resistance should be 31-58 ohms for the #1 W/WS and 60-100 ohms for #4 W/WS. Sensor resistance for #1 W/WS is temperature dependent, and should be 305 to 320 ohms at 70° F. The #4 W/WS does not have an integral sensor.

Electrical insulation integrity was checked using a Hipotronics 300 Series Hipot and Megohmmeter at 2500 volts A.C. On #1 W/WS, insulation integrity was checked between the power bus and the sensor element, sensor element and the metal frame retainers, and from sensor element to sensor element. On #4 W/WS, the integrity was checked between the power bus and the metal frame retainers. Only a pass or fail rating is considered.

4.3.1.4 Heater Operation Tests

Sensor operation and heating uniformity were evaluated by infrared imaging. In this test, the W/WS was powered with 60 Hertz power at a voltage appropriate to the W/WS heater resistance. During the power up, the ability of the W/WS sensor to regulate the

temperature was established. When thermal equilibrium was attained, an infrared imaging system was used to make a photograph of the thermal contours on the glass.

To supplement the thermal imaging heater test, a scratch test of the heater film was performed. In this test, the heater is powered up (350 volts A.C. for #1 W/WS, 81 volts A.C. for #4 W/WS) and the W/WS is viewed using polarized light. Although the vinyl core ply of the W/WS is birefringent, scratches in the heater film show up dramatically as black-gray starbursts. A pass-fail rating on the scratch test is given.

4.3.1.5 Optical Performance

The optical performance of each W/WS was assessed in three ways; a haze and luminous transmittance test, an optical deviation measurement, and an optical distortion test.

Haze and luminous transmittance measurements were performed in accordance with ASTM D-1003-92, "Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics." The luminous transmittance test measures how transparent a body is, and is the ratio of the light transmitted through a body to the light incident upon it. The haze test measures the cloudy appearance of an otherwise transparent specimen caused by light scattered from within the specimen or from its surfaces. Haze and luminous transmittance measurements will detect whether the repair processes have adversely affected the clarity and/or coloring of the vinyl and whether the glass surfaces have been adequately polished. The haze and luminous transmittance measurements were made using a Pacific Scientific XL-211 Hazegard System hazemeter at the center of each W/WS. Per Mil-G-25871B (Military Specification: Glass, Monolithic, Aircraft Glazing) Paragraph 3.7, the original luminous transmittance should be greater than 72 percent and 78.4 percent for #1 and #4 W/WS, respectively. The original haze of a transparency greater than 0.62 inches thick should be less than 2.5 percent, per Mil-G-25871B Paragraph 3.9.

Optical deviation measures the flatness of a transparency. In the case of a repaired W/WS, grinding, polishing, and/or uneven pressing to remove delaminations may cause the front and back surfaces of the W/WS to deviate from a parallel condition, causing images to be deformed. PPG's "German Light," measures the flatness of a transparency using the distance between the front surface reflection of a normally directed beam of light and the light reflected from the back surface of the transparency to calculate the angular deviation from parallel. Measurements are given in terms of minutes of angular arc.

Optical deviation was measured using MIL-G-25871B Paragraph 4.4.6.2.1 as a reference at 8 locations on #1 W/WS and at 4 locations on #4 W/WS. The measurement locations were principally around the edges of the W/WS where deviation is expected to be most severe in a relaminated W/WS. Deviations under 4.5 arc minutes are considered acceptable anywhere 2 inches in from the forward edge, top and inboard edges and 4 inches in from the aft edge on #1 W/WS. Deviations of up to 9 arc minutes are acceptable in the

#1 W/WS edges. Deviation for the #4 W/WS is much less stringent than for #1 W/WS, 18 arc minutes anywhere 2 inches in from the edges.

Optical distortion was assessed using MIL-G-25871B Paragraph 4.4.6.3 as a reference. The distortion was determined by a single-exposure photograph of a grid viewed through the W/WS. Photographs were made with the W/WS parallel to the grid board. There is no reference specification for distortion for these W/WS. A distortion of greater than 1 part in 40 is essentially no distortion. As a reference, MIL-W-81752A sets a distortion limit of 1:15 for Navy fighter/attack aircraft. A 1 part in 4 distortion would probably be considered unacceptable for the #4 C/KC-135 W/WS.

4.3.2 General Inspection Test Results

Tables 4.1 through 4.8 summarize the results of the general inspections. In a number of areas, the repaired W/WS are the equivalent of new W/WS - dimensional fit, optical properties, and heater operation. There are, however, some troublesome areas - seals, unremoved delaminations, some insulation integrity faults, and a few out of specification heater resistances that suggest that the repaired W/WS are not quite up to OEM standards for a new W/WS. As indicated, most of the general inspection tests had an accept/reject criterion. For the heater tests and optical distortion, there are no established criteria. Figures 4.1 and 4.2 show thermal images from the heater tests. Figures 4.3 and 4.4 show the worst optical distortion found during the inspections. Appendix B contains the data sheets for the general inspections.

In addition to the general inspection data summarized in the tables and figures, two interesting items worth noting came to light. First, there was one commercial fleet W/WS in the program, and second, the new #1 W/WS were surprisingly old.

One of the #1 W/WS, S/N 83-H-11-7-432, has a commercial part number, 5-89354-3096, instead of the expected military part number 5-89354-501 (pilot side #1). Superficially, the two W/WS look identical and can be interchanged. The commercial #1 W/WS, however, unlike the military #1 W/WS, does not have slip planes and edge heaters. Rather, the slip planes and edge heaters of the military #1 W/WS have been replaced by a PPG-proprietary urethane ply. From the discussion in Section 2.1 about the construction of the C/KC-135 W/WS, the slip planes are areas around the edge of the W/WS where the glass has been prevented from bonding to the vinyl so that the edge of the glass does not become overstressed during thermal expansion. The urethane ply in the commercial W/WS accommodates the differential thermal expansion with a fully bonded W/WS structure. The edge heaters keep the vinyl "soft" in the W/WS corners. According to PPG, the urethane layer in the commercial W/WS reduces the tendency for delamination and edge chipping, and does not degrade any of the other properties of the W/WS. PPG feels that the commercial W/WS is superior to the military counterpart.

The new #1 W/WS were manufactured in 1986. This suggests that either the W/WS inventory at Tinker AFB is not maintained on a first-in first-out basis, or that reorder

quantities are large and that it takes a long time to deplete the stock. In any event, because of the potential time lag between manufacture and installation, manufacture date is not a good indicator of possible service life. Some of the new #1 W/WS were made several years before some of the W/WS that were repaired, and so it is not appropriate to assume that W/WS with older serial numbers have seen more service. Whether or not this is common to all of the W/WS in the inventory is not known, but it is something to consider if a service life limitation is imposed that does not track actual use.

4.4 Pressure Integrity

4.4.1 Test Procedures

Pressure integrity was evaluated with a three-step sequence. The first step was a proof pressure test. Samples which passed the proof pressure test then went on to a cyclic pressure durability test. Finally, samples which passed the cyclic durability test were proof pressure tested again.

4.4.1.1 Proof Pressure Test

This test was performed as an initial acceptance and final test on all pressure integrity test articles. The test candidates were mounted in a test fixture and pressurized at a rate not exceeding 0.84 psi per minute to 1.33 times the C/KC-135 relief valve setting of 9.42 psi (12.59 psig). The maximum pressure was held for 15 minutes and then released at a rate not greater than 0.84 psi per minute. The test was conducted at ambient temperature. At completion of the test, the W/WS was inspected for delamination and electrical resistance.

The data requirements for the proof pressure test consisted of pressure-time records and the post-test delamination inspection and electrical resistance measurements. For test articles that did not hold pressure due to breakage or cracking, a photograph of the failed W/WS was required.

The criterion for failure of the test was inability to hold pressure due to cracking or breakage. Delamination or failure of the heater to operate were to be noted, but were not sufficient to disqualify the specimen from further testing.

4.4.1.2 Cyclic Durability Test

This test was performed on all W/WS that passed the initial proof pressure test. The test was conducted with an outward-acting constant amplitude cyclic pressure varying from 0.00 to 9.42 psig, applied at a rate not greater than 0.84 psi per minute. The inboard side of the W/WS was to be held at room temperature (72° F ± 10° F) and the outboard side was to be at -65° F ± 10° F with the heater energized. The cyclic pressure was to be applied until failure was observed or run out, with run out calculated to simulate a 10 year life for a

C/KC-135 (520 cycles). Test article inspections were to be performed at 5 years of simulated service and at the conclusion of the test.

The data requirements for the cyclic durability test consisted of pressure, inboard side air temperature, outboard side air temperature, and bus-to-bus resistance, all as a function of time. Marking of delaminations on the surface of the outer ply and then photographing the W/WS served to document any visual damage to the W/WS. Mode of failure and a photograph of the failed test article were to be used to document specimens that did not survive this test.

The criterion for failure in the cyclic durability test was inability to hold pressure due to cracking or breakage. Failure of the heater was to be noted, but was not sufficient cause to stop the pressure cycling.

4.4.2 Test Facility

The test facility for conducting the pressure integrity testing utilized PPG's Environmental Qualification Test Facility. This facility has three walk-in environmentally controlled chambers that can be used to expose transparencies to temperatures as low as -100° F and as high as +185° F. Pressure chambers with mounting flanges for transparencies fit into the wall of the environmental chambers to permit simultaneous pressure and temperature control, per Figure 4.5. Internal heating and cooling capacity, as well as small fans inside the pressure chambers ensure that the transparency inboard side conditions can be maintained, independent of the outboard side conditions. The facility is controlled by 16-bit Macsym 350 process control computers that manage the temperature and pressure in real time, and perform data acquisition.

Each W/WS was instrumented with 4 thermocouples, two inboard and two outboard, one directly on the glass surface and one 1-inch off the surface. A strain-gage-based pressure transducer was used to measure the pressure chamber pressure.

The #1 W/WS heaters were powered by a 400 Hertz 0-500 volt A.C. motor-generator set adjusted to generate an output voltage consistent with the W/WS bus-to-bus resistance. On the #1 W/WS, the integral sensor was used to control the temperature. The #4 W/WS were powered by 70 volts A.C. 60 Hertz power derived from 120 volt A.C. building power. This voltage is consistent with T.O. 1C-135(K)A-2-2 Paragraph 8-9. The temperature of the #4 W/WS was controlled using a thermocouple-based temperature controller set to have the same operating characteristics as the thermal snap switch that is found on C/KC-135's per T.O. 1C-135(K)A-2-2 Paragraph 8-10: control point about 100° F, switch closure at 90° ±10° F, switch opening at 110° ± 10° F.

The pressure integrity test W/WS were mounted in simulated frames per the drawings shown in Figures 4.6 and 4.7. The rationale for using simulated frames was; 1) less expensive than using an actual fuselage section, and 2) a simulated frame could be made

much stiffer than the sheet metal fuselage section and thus would maximize potentially damaging deformation in the W/WS.

The #1 W/WS were bolted to the frame shown in Figure 4.6 using hardware equivalent to that used in the actual aircraft W/WS installation kit, per Figure 4.8a. Unlike the actual aircraft installation, Grade 8 socket head cap screws and nuts were used. Aluminum washers similar to the ones in the installation kit were used. No curtain clips or wire clamps were installed. Bolt torques and tightening sequences followed T.O. 1C-135(K)A-2-2 Paragraph 8-55. One #1 W/WS was tested at a time. Figure 4.9 shows a #1 W/WS in the pressure test facility.

The #4 W/WS were installed using 16-gauge sheet metal retainers and silicone rubber gasket strips fabricated to simulate those used in the aircraft, Figure 4.8b. Grade 8 socket head caps screws and nuts were used instead of actual aircraft bolts and nuts, with no curtain clips or wire clamps. Bolt torques and tightening sequences followed the prescriptions in T.O. 1C-135(K)A-2-2 Paragraph 8-61. Two #4 W/WS were pressure tested at a time, as shown in Figure 4.10.

4.4.3 Test Results

The results of the pressure integrity testing are presented in Tables 4.9 and 4.10. None of the W/WS, repaired, not repaired, or new, exhibited any catastrophic failures. Two of the repaired W/WS did experience delaminations, while no evidence of delamination was detected in the new W/WS. Figure 4.11 shows the worst delamination observed in a #1 W/WS. Figure 4.12 shows the worst delamination observed in a #4 W/WS. In these figures, the edge of the delamination has been outlined with a black marker. The delamination in the #1 W/WS would not interfere with pilot vision, and may not even be noticed. The delamination in the #4 W/WS, would, most likely, be noticed and reported by a pilot.

A curious "healing" phenomenon was noted in some of the W/WS. Immediately after the pressure cycling, the W/WS were examined for delamination and a marker was used to outline its edge. Some time later, after the W/WS had returned to room temperature, the extent of the delamination was observed to have reduced. Residual stresses in the W/WS cause the delaminations to close up. Discussing this point with the PPG staff confirmed that the "healing" phenomenon is not unique to our tests. PPG indicated that they occasionally get W/WS back on warranty that do not appear to be damaged in any way. Applying some thermal and pressure cycles to the W/WS is generally sufficient to open the delaminations. Although the consequences of this phenomenon for this program are nil, it does suggest that a pilot or copilot could report diminished vision in a W/WS that may not be detectable by the ground crew.

4.5 Residual Strength Assessment

4.5.1 Test Procedures

The residual strength of a selected subset of the W/WS that passed the pressure integrity tests was assessed with a falling ball impact test. In this test, a spherical steel ball was dropped onto the W/WS using Mil-G-25871B Paragraph 4.4.3 as a reference, see Figure 4.13. Unlike Mil-G-25871B where the purpose is to make certain that no separation or delamination of glass from the vinyl occurs, the purpose of this test was to see if repaired W/WS that have been pressure cycled have a reduced capacity for moderate impacts.

The procedure for conducting the falling ball impact tests was to establish a suitable ball weight and drop height to cause significant outboard ply damage without breaking the core ply of a new W/WS that had passed the pressure integrity tests, and then test a few of the remaining W/WS under these conditions.

In the case of the #1 W/WS, a 2-pound ball dropped from a height of 15 feet broke the outer glass ply and crushed the glass in the impact area with a web of cracks emanating from the impact site. Because of the size of the #1 W/WS, two ball drops could be performed, in some cases. For the #4 W/WS, a 1-pound ball dropped from 15 feet did similar damage. A single drop was done on #4 W/WS.

4.5.2 Test Facility

The test facility for conducting the ball drop consisted of a drop tower with ball guide tube and electromagnetic ball release mechanism, and a support frame for the W/WS. Because the PPG ball drop facility was designed only to accommodate small test panels and not full W/WS, boundary conditions at the W/WS edges could not be freely prescribed and a center drop on the #1 W/WS could not be done. Rather, the W/WS were supported by a square frame with a 1-foot by 1-foot opening on the face of the bottom (inboard) glass ply. Due to a space restriction, approximately half of the #1 W/WS extended beyond the support frame, but was supported at the same height as the impact target area. Because all W/WS were treated consistently, the somewhat imprecise nature of the boundary is not as issue.

4.5.3 Test Results

Tables 4.11 and 4.12 detail the results of the falling ball residual strength impact testing, while Figures 4.14 through 4.19 show the test set-ups and selected consequences of the impacts. The results of the ball drop are not conclusive because only a single new W/WS was tested of each type. The worst damage occurred in repaired W/WS with delamination, so there appears to be a suggestion that the ball drops do more damage to the repaired W/WS than the new W/WS.

4.6 Bird Impact Testing

4.6.1 Test Procedures

The bird impact testing was conducted using ASTM F330-89, "Bird Impact Testing of Aerospace Transparent Enclosures" as a model. The W/WS were mounted in a simulated frame placed at the correct inclination and sweepback angles for level flight and impacted with a real 4-pound bird in the center at 250 knots. Testing was done at room temperature, performing a single shot on each W/WS. A spall sheet was placed behind the W/WS.

The simulated frames used in the bird impact tests were similar to the ones used in the pressure integrity tests, Figures 4.20 and 4.21. The rationale for using simulated frames was the same as in the case of the pressure integrity tests. Mounting hardware and installation procedures were consistent with the applicable C/KC-135 Tech Order, T.O. 1C-135(K)A-2-2. Figure 4.22 shows the bolts, O-rings, washers, and nuts used to secure a #1 W/WS in the test frame.

The #1 W/WS were inclined 45 degrees with a sweepback angle of 30 degrees, while the #4 W/WS were inclined 58.12 degrees with a sweepback angle of 35.3 degrees, per information obtained from Boeing and verified by measurement on a C/KC-135 by OC-ALC. The reference for the inclination angle is a vertical line. The reference for the sweepback angle is a horizontal line normal to the centerline of the aircraft. The #1 W/WS as installed presents a fairly large target for the bird package. Because of the size and oblique installed angle, the bird package nearly fills the #4 W/WS.

The data requirements for the bird impacts tests consisted of a pre-test photograph, bird weight, high speed film of the impact, impact velocity, a post-test photograph, a record of the disposition of the spall sheet, and written comments from a post-test examination of the W/WS.

4.6.2 Test Facility

PPG's bird impact test facility is one of the most advanced in the world, capable of shooting one to eight pound birds at impact velocities from 29 to 751 knots, depending on the bird weight. The pneumatic cannon has a 40-foot long barrel with a nominal 10-inch diameter. A pressurized reservoir provides compressed air to propel a metal can, called a sabot, containing the bird to the target. When the sabot reaches the end of the barrel after firing, it is collected by a stripper and spring system that absorbs the sabot's kinetic energy. As the bird continues to the target, approximately 10 feet away, it passes through a timing trap system to measure its velocity. Figure 4.23 shows a schematic of the important elements of the bird cannon.

The velocity of the bird at impact is a calibrated function of the air pressure pushing the sabot down the barrel. A dual rupture diaphragm system fires the gun. Assuming that

Diaphragms 1 and 2 in Figure 4.23 are rated to burst at P_b psi and that test pressure, P_t, is greater than P_b but less than $2P_b$, putting $\frac{1}{2}P_t$ in the Step Chamber keeps both diaphragms from bursting. Opening the Solenoid Exhaust Valve vents the Step Chamber to atmosphere and causes Diaphragms 1 and 2 to burst almost simultaneously applying test pressure in the reservoir to the sabot.

A massive frame support system, adjustable for inclination angles from 25 to 85 degrees was use to hold the simulated W/WS frame. Figure 4.24 shows the support frame with a #1 W/WS mounted. Figures 4.25 and 4.26 show views of W/WS mounted and ready for testing. To ensure that the test article is in its proper position, the impact point is identified with a helium/neon laser centered in the end of the barrel. Installation angles were measured with a precision clinometer.

High speed photographic records of the impacts were made with up to three 16-millimeter cameras operating at up to 11,000 frames per second. The cameras and lighting system are tied into the cannon firing system so that when the fire button is depressed, the lighting is switched on, the cameras come up to speed, and an internal camera speed signal fires the gun. Typically, two cameras recorded the impact from the front, while the third camera recorded the impact from the rear.

Bird speed is measured in three axes and averaged to compensate for minor deviations in the bird package's flight pattern prior to impact. Basically, the time for the bird package to traverse a fixed distance is measured and converted to velocity. Because the timing system requires more than 50-percent of the timing system lights to be obscured, false time readings and consequent incorrect speed indications triggered by small particles or moisture clouds that precede the bird package are eliminated. Figure 4.27 shows the velocity timing trap and front camera positioning.

A spall sheet was placed at the pilot's head position to determine if any glass fragments or bird residue comes through the W/WS in the event of a failure. In Figure 4.25, the spall sheet can be seen behind the W/WS as a black rectangular sheet slightly left of center. Figure 4.28 shows the spall sheet from behind a #1 W/WS.

4.6.3 Test Results

A summary of the bird impact test results is presented in Tables 4.13 and 4.14. A gradation in impact damage for #1 W/WS is shown in Figures 4.29 to Figure 4.34, ranging from no damage to all glass plies failed. A similar gradation of bird impact results for #4 W/WS is shown in Figures 4.35 to 4.40. Other W/WS with similar damage look about the same as these figures. The bird impact data sheets are attached as Appendix C.

Concerning the test comments about bird residue on the spall sheet, it must be noted that the simulated frame had no aerosmoother sealant between the frame and the transparency. Furthermore, there was no cosmetic trim pieces on the inside of the W/WS.

Either one or both of these would probably have prevented bird residue from squeezing between the W/WS and the frame. Ply breakage would not be affected by the presence of aerosmoother or trim pieces.

4.7 Performance Testing Summary

The performance testing data have been summarized in Tables 4.15 to 4.18. From these summaries, the obvious conclusion is that used W/WS do not perform as well as new W/WS. Although trends are difficult to identify in the data because there always seem to be exceptions and because the data base is so small, the performance of W/WS that have been in service, whether repaired or not, is below that of new W/WS.

In a number of categories, the repaired W/WS were the equal of new W/WS: dimensional fit, optical properties, and heater performance. In other cases, they were not: residual delamination, seals and bumpers, delamination during pressure cycling, more damage in the ball drop test, and poorer performance in the bird impact testing. Some of the issues such as seal and bumper problems and residual delamination can easily be rectified. The delamination during pressure cycling is merely annoying because it is an impaired vision issue that would develop over time and is not a serious structural failure.

The bird impact test results are conclusive. The new W/WS performed significantly better than the repaired and not repaired W/WS. At worst, the outboard ply of a new W/WS was broken. For the repaired #1 W/WS, fully half of the samples had all three plies fail, although none had bird penetrations. For the repaired #4 W/WS, only an outboard ply was broken. The unrepaired #4 W/WS performed the worst in the bird impact tests, with one whole W/WS punching out of the frame. This W/WS was rejected for repair, but it appears that it was for an out-of-specification heater and not for any unrepairable structural deficiency. Similarly, the other two unrepaired #4 W/WS that were damaged were also rejected for out-of-specification heaters. The fact that repaired W/WS performed somewhat better than unrepaired W/WS seems to indicate that the repairs themselves do not degrade the W/WS.

Some of the repaired #1 W/WS had a reduced thickness in the edge attachment area. The reduced mounting edge thickness was noticed when bolts that had previously worked satisfactorily for mounting new W/WS in the frames for bird impact tests appeared to be too long. Basically, the bolts would bottom-out on the aluminum spacers in the phenolic mounting block before the W/WS was tight to the frame (see Figure 2.4). The reduction in frame thickness could have been caused by extrusion of the vinyl inner layer during the relamination repair process, it could have occurred as a result of creep during service, or it could be an artifact of the original manufacturing processes. Table 4.19 summarizes edge measurements that were made on the #1 bird impact W/WS and a set of unrepaired W/WS that were not part of the rest of this program. Reduced mounting edge thickness appears to correlate with more severe impact damage, but does not correlate with age or whether or not the W/WS has been repaired.

5.0 COST ANALYSIS

The second element in the evaluation of the feasibility of using repaired W/WS in Air Force fleet aircraft was a cost analysis. The commercial fleet has a very favorable cost benefit using repaired W/WS. If using W/WS is to be a viable option for the Air Force, the costs for making the repairs has to be justifiably less than the cost of a new W/WS.

5.1 Repair Costs

During initial contacts with NORDAM, Perkins, and The Glass Doctor and prior to contracting for any repairs, an estimate was solicited for repairing small numbers of each of the five C/KC-135 W/WS types. NORDAM prices their repairs on the basis of how much work is required to do the repair, i.e., a W/WS that only needs polishing costs less than a W/WS that needs polishing and relaminating, and thus they could only give rough estimates. Perkins has a fixed price for repairing a given type of W/WS, regardless of the number of steps required to repair the W/WS, and offers up to a 30-percent discount for large volume customers. The Glass Doctor offered a fixed cost per W/WS type. All of the repair vendors perform incoming inspections and reject unserviceable W/WS, charging only for those that they successfully repair. Table 5.1 summarizes the initial repair quotations from the three vendors.

The actual costs for making the prototype repairs on the #1 and #4 W/WS that were performance tested are listed in Tables 5.2 and 5.3. Actual costs were consistent with the initial repair estimates. For reference, Table 5.4 summarizes the quoted repair cost for all 75 of the C/KC-135 repair candidate W/WS that were procured for this program. The latter table reflects the incoming W/WS inspections performed by NORDAM and Perkins.

5.2 Costs of New W/WS

OC-ALC provided costs for new C/KC-135 W/WS. The data in Table 5.5 is the Air Force purchase price as of January 1994.

5.3 Cost Comparison

The average cost for making the prototype repairs on the C/KC-135 #1 W/WS was $1,943, while the average cost of making the prototype repairs on the #4 W/WS was $899. Comparing these numbers to the current purchase price, the repairs cost 75-percent of the purchase price of a new #1 and 65-percent of the purchase price of a new #4.

Taking the extremes of the initial repair estimates, actual repair costs, or cost quotes from NORDAM and Perkins, and assuming a large enough volume so that Perkins would offer a 20-percent volume discount, the best-case, actual, and worst-case cost scenarios for repaired C/KC-135 W/WS are as shown in Table 5.6. Had The Glass Doctor participated in the program and repaired W/WS at the prices in their estimate, the low values in Table 5.6

would have gone to 51-percent for #1 W/WS, 62-percent for #2 W/WS, and 34-percent for #3 W/WS.

6.0 CONCLUSIONS, RECOMMENDATIONS, AND DISCUSSION

6.1 Conclusions

The Air Force, in an effort to reduce fleet maintenance costs, is considering the possibility of using repaired W/WS. Prior to adopting such an operating policy, however, the Air Force decided that a systematic evaluation was required to ensure that repaired W/WS are safe and that they provide a reasonable cost savings benefit. Based on the reported cost savings and favorable experience that the commercial fleet has had with repaired W/WS, the use of repaired W/WS seems very attractive.

The approach followed for evaluating whether the use of repaired W/WS is a viable option for the Air Force was to procure some used W/WS, make repairs on them, and then subject the repaired W/WS to a series of tests to determine the difference in performance when compared with new W/WS. The cost to make the repairs provides the data for the cost benefit analysis. The test results provide the data for an evaluation of fitness for purpose of the repaired W/WS.

The test results indicate that repaired W/WS are not equal to new W/WS. Many of the repaired W/WS still contain defects that would not pass an OEM quality assurance inspection. None of the W/WS, new, repaired, or not repaired, exhibited any dramatic differences in pressure integrity. Some delamination occurred in two of the repaired W/WS during pressure cycling, but it was not severe. The residual strength of the pressure cycled W/WS tends to suggest that the repaired W/WS are not quite as good as new W/WS. The bird impact test results are quite clear - the new W/WS outperform either repaired or unrepaired W/WS.

Having established that repaired W/WS are not equal to new W/WS, the question that remains to be answered is whether or not repaired W/WS are "good enough." The replacement criteria in the C/KC-135 W/WS Technical Order, T.O. 1C-135(K)A-2-2, are founded on two major principles:

1) A W/WS that has any condition that impairs visibility must be replaced

2) The W/WS heater must function properly.

A number of specific inspection items, subordinate to these principles, provide additional criterion for W/WS replacement. According to the prevailing Tech Order inspection criteria, none of the repaired W/WS would have been removed for cause from service. The fact that they were removed and were subsequently restored to a condition better than the W/WS

replacement criterion suggests that they were in fact "good enough." The repair vendors do not claim that they can restore a W/WS to a brand new condition. Rather, they indicate that the repairs they perform return the W/WS to a fully acceptable and functional condition. Under this philosophy, the repaired W/WS do appear to be "good enough."

In terms of performance, the most demanding test is the bird impact. Using the criteria set forth in MIL-W-81752A (Windshield Systems, Fixed Wing Aircraft General Specifications For), Paragraph 3.7.2 specifies that the W/WS should be able to sustain a 4-pound bird impact at maximum achievable operational true airspeed in level flight at up to 5000 feet altitude without any spall. This is substantially the same requirement for commercial fleet W/WS set forth in "Part 25 - Airworthiness Standards: Transport Category Airplanes" of the U.S. Federal Aviation Regulations, Paragraph 25.775. The velocity prescription dictated by MIL-W-81752A and FAA 25.775 is operationally restricted, however, by Part 91, Paragraph 91.117 of the FAA Federal Aviation Regulations which states that 250 knots is the maximum allowable aircraft speed below 10,000 feet above mean sea level without special authorization. Assuming that the 250 knot impact velocity is the proper performance criterion, all of the new and repaired #1 and #4 W/WS meet the no bird penetration requirement, while two of the repaired #1 W/WS technically fail the no spall criterion. From a practical viewpoint, the spall was very modest, so the repaired W/WS appear to be "good enough."

The lone W/WS that experienced a catastrophic bird impact failure (#4 W/WS, S/N 7-H-2-4-35) was not repaired. Reviewing the repair vendor's report on the W/WS, it was rejected for repair due to a heater that was out of specification and not for any gross structural deficiency, such a vinyl cracking or delamination. The only other vendor-reported damage was scratches. The Air Force HOWMAL (how malfunctioned) comments on the removal tag indicated that it had a burnt discoloration in the corner at the edge of the heater. The fact that the heater was defective suggests that the W/WS may have been subjected to in-service pressure cycles with the vinyl unheated. This would have been hard on the glass-vinyl interface, because the vinyl would have been relatively brittle, predisposing the W/WS to fail in the bird impact test. On the other hand, if the heater had been satisfactory, the W/WS probably would have been polished and considered repaired. Because the vinyl itself failed, it is unlikely that polishing would have changed the outcome of the test.

The bird impacts done for this program represent the first ever C/KC-135 W/WS bird impact tests. In addition to demonstrating that repaired W/WS are probably "good enough," the work in this program has confirmed that the basic C/KC-135 W/WS design is adequate.

The new #1 W/WS used in this program were manufactured in 1986. The fact that they performed well in all of the tests, in spite of sitting in warehouse storage for 7 years, indicates that these W/WS do not degrade in storage. This is quite important when considered in the context of a possible blanket 10-year replacement policy, because the only method available now to track the 10 years is by manufacture date. To implement a

meaningful 10-year W/WS replacement cycle policy, it would be necessary to track individual W/WS service history.

The cost analysis indicates that savings may be realized. For this program, the cost of making the repairs was 75-percent of the new W/WS purchase price for #1 W/WS and 65-percent for the #4 W/WS. Considering all five of the C/KC-135 W/WS types and the full range of estimates, quotes, and actual costs, repairing a W/WS might cost as little as 41-percent of a new W/WS, but it could also cost as much as ~~1~~32-percent higher than a new W/WS.

The costs quoted are only the direct repair costs. To this must be added the direct cost of transportation and the indirect costs of procuring the service (contracting - more vendors will be involved), administrating ~~it~~ the service (accounts payable, records management, QA inspection of the vendors, etc.) and operating ~~it~~ the service (storage, shipping and handling, outgoing/incoming inspection, etc.). These items will certainly make the economics less favorable and to ignore them would be a false economy. On the positive side of the economic issue, the repair vendors do not directly charge for W/WS inspections or for any repair work that does not result in a shippable W/WS. The cost, both economic and environmental, of disposal of all of the W/WS that are currently removed and sent to a landfill cannot be ignored. Repaired W/WS would certainly have an advantage here.

A final consideration of an economic nature that must be factored into the decision to use repaired W/WS is new W/WS availability. There may be a persuasive economic reason to use repaired W/WS if new W/WS are in short supply. The repair vendors could probably be queued up to make repairs, basically on demand, and could provide a "just in time" service. As opposed to having aircraft out of service because new W/WS were not available, repaired W/WS could be used.

6.2 Recommendations

Recommendations that can be made as a result of the work performed on this program are contingent upon the Air Force making a decision, based on the available data, that the performance of repaired W/WS is acceptable.

If, in the opinion of the Air Force, the performance of repaired W/WS is deemed "good enough:"

1) NORDAM Transparency Division, and Perkins Aircraft Services, Inc. are recommended as vendors. No recommendation can be made regarding The Glass Doctor, because they supplied no test articles for this program.

2) Based on the results of this study, the repair processes that can be recommended are:

   a) Relaminating using autoclave processes involving application of heat and pressure
   b) Grinding and polishing of the external surfaces of the glass
   c) Seal/bumper maintenance
   d) Minor clean-up of electrical terminals

3) Repair processes that cannot be recommended at this time by virtue of not having been used in this program are:

   a) Complete replacement of a glass ply
   b) Delamination or crack repair involving injection of adhesives or filling with transparent polymerizable resins
   c) Sensor replacement
   d) Busbar/heater wire repair/replacement

4) A formal Air Force quality assurance (Q/A) program should be instituted to set forth requirements for the repair vendors. This will eliminate the annoying, but easily corrected, problems with wrong seals/bumpers on repaired W/WS. In addition, this Q/A program should also be charged with performing an incoming inspection of W/WS coming back from the repair vendors.

5) A policy that prevents a W/WS from undergoing more than one repair cycle should be instituted. The contractual requirements for the repair vendors should stipulate that all repaired W/WS must be marked to identify that they have been repaired and by whom. No data have been collected to support the use of re-repaired W/WS.

6) The Air Force should use the cost data in this report as the starting point for a complete cost/benefit analysis to satisfy themselves that there is an economic advantage to using repaired W/WS. Full costs, including all direct and indirect cost for labor, materials, and facilities must be included. This must be done on a W/WS by W/WS basis, because the data from this program suggest that some W/WS can be replaced at less cost than they can be repaired.

It is important to emphasize that all of the recommendations offered above are contingent on the Air Force deciding that the performance of the repaired W/WS is adequate.

6.3 Discussion

In reviewing the test data, the question of why one W/WS should perform better or worse than another in a structural test was considered. Four possible causes were identified:

- Vinyl degradation - Vinyl, being a plastic is subject to UV degradation and general aging due to loss of plasticizer. As a result of the aging, the vinyl may become brittle and crack, thus reducing its load carrying capacity in the laminate. The vinyl could also be preferentially squeezed from the edge of the W/WS during a relaminating repair process or in service. Because the vinyl is the only structural ply that carries the load into the W/WS frame for a bird impact, if this occurred, the load capacity of the W/WS would be degraded.

- Grinding/polishing of the glass - The C/KC-135 W/WS use heat-strengthened glass. In producing this type of glass, the ply is heated to near its softening point and then quenched to introduce compressive residual stresses in the surface layers as shown in Figure 6.1. Tensile stresses inside the glass exist to equilibrate the compressive surface stresses. Because glass only fails due to tensile stresses at the surface, the residual compressive stresses must be overcome to initiate a failure. Grinding and polishing remove some of the beneficial compressive stresses, and hence, the overall strength of the glass ply is reduced. Removal of the highest compressive stress layer, however, must be balanced against removal of flaws. In concert with the obvious effect of removal of the highest compressive stress layer, as far as flaw tolerance goes, the surface may also not be as smooth after grinding/polishing. Smoother surfaces have less flaws and a profoundly higher strength[11].

- Stress corrosion cracking of the glass - The surface of glass contains many microscopic cracks and fissures, and under a sustained load, the presence of moisture exacerbates the growth of these cracks[12-15]. Generally, water vapor in the air is sufficient to cause the degradation. Elevated temperatures and longer exposures accelerate the stress corrosion cracking effect. Although there is no direct evidence that aircraft W/WS degrade dramatically from this phenomenon, the fact that the W/WS are highly stressed due to thermal and pressure loading, they are exposed to atmospheric moisture, they are routinely heated in a high stress state, and that old W/WS performed below new W/WS in the structural tests suggests that there may be more than a casual cause-effect relationship.

- Fatigue - Glass exhibits a complex load rate-cyclic loading behavior. Under a constant maximum load, no effect of cyclic loading is observed, but under increasing maximum load, cyclic loading reduces the strength[16,17]. The net effect for a W/WS undergoing repeated pressure cycles is not clear, but it seems plausible that some amount of micro-crack propagation occurs.

There is no conclusive evidence that the results of this test program can be directly attributed to any of the mechanisms described above. However, it does not seem unreasonable to suggest that they might. As far as the implications for use of repaired W/WS, vinyl degradation, stress corrosion cracking, and fatigue affect both repaired and unrepaired W/WS. Only repaired W/WS would seem to be susceptible to the grinding/polishing degradation mechanism.

It would be nice to be able to make generalizations about some W/WS being better repair candidates than others, possibly based on age. Unfortunately, there is just too little data to support such generalizations. There are enough inconsistencies in the data, i.e., new W/WS older than some of the repaired ones, some very old W/WS performing just as well as new W/WS (1971 manufacture #1 W/WS S/N 1-H-10-5-480 pressure cycle and ball drop, 1974 manufacture #4 W/WS S/N 4-H-10-9-69 bird strike), etc., that one cannot readily see trends in the data. To try to treat the test results in a statistical manner, looking for correlations, just does not make any sense with such small sample populations. The best that one can say is that repaired W/WS are not equivalent to new W/WS.

It is unfortunate that The Glass Doctor declined to participate in this program. The repairs that The Glass Doctor makes are unique, and based on their cost estimates, quite inexpensive. The long-term performance of the materials that The Glass Doctor injects into the W/WS may be a concern, particularly in terms of extended exposure to ultra-violet radiation. The quality assurance aspect of not being certain of what is being injected in any given repair is also of concern. On the other hand, The Glass Doctor does warranty repairs, other than improper handling, for up to three years.

The issue of commercial construction W/WS versus military construction W/WS deserves some comment. According to PPG, back when Boeing 707's were first coming into service, chipping of the outer ply glass in the corners was common and was attributed to uneven W/WS heating causing differential thermal expansion/contraction of the glass and the underlying vinyl. The slip planes in the current C/KC-135 W/WS are there to help control this problem. To completely eliminate the problem, Boeing tried sewing fine wires in with the vinyl, so-called edge heaters, to keep the vinyl "soft" in the W/WS corners. This was not very successful, because no additional power was applied to the W/WS and failure of the edge heaters was common. A second solution, was to put external glue-on edge heaters on the inside of the W/WS. This approach, unfortunately, does not put the heat where it is needed - at the outer glass ply to vinyl interface. The final solution, which is the current commercial W/WS standard, was to put a thin layer of polyurethane between the vinyl and the outer glass ply. Because the polyurethane is more ductile and does not bond as tightly to the glass as vinyl, the glass and vinyl can move somewhat independently. The polyurethane layer, which could simply be added to the existing W/WS because of the large tolerances on glass and overall assembly thickness, eliminated the edge cracking problems and did away with the need for slip planes and edge heaters. The cost of a polyurethane layer W/WS is something less than 10-percent higher than the cost of a vinyl-only W/WS. The polyurethane is itself significantly more expensive, but this is balanced against less labor because the slip

planes and edge heaters are eliminated. For commercial fleets, the higher cost is justified on the basis of more flight hours between W/WS replacements. For C/KC-135's, because they do not see nearly the flight hours per year that commercial planes see, the cost to benefit ratio for the technically superior polyurethane layer W/WS may not be low enough.

7.0 REFERENCES

1) MIL-W-81752A, "Windshield Systems, Fixed Wing Aircraft General Specification For."

2) Kelley, M.E., "Aircraft Transparency Testing Methodology," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

3) Bain, P.H., "An Industry Test Program for Interlayer Equivalency," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

4) King, R.D., and Wright, R.W., "Glass in High Speed Transport," *Glass Technology*, Vol 28 No 2, April 1987, pp. 73-81.

5) Hornsey, W.W., Rothe, W.F., "New Aircraft Windshield Applications Using Ion Exchange Glass," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

6) MIL-G-25871B, "Military Specification; Glass, Laminated, Aircraft Glazing."

7) Campbell, L.G., and Marshall, J.W., "Windshield Flight Environment Simulator," *Aircraft Engineering*, March 1976, pp. 4-9.

8) Lawrence, J.H., "Windshield Weight Reduction Through Use of High-Strength Glass and Polyurethane Interlayers," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

9) U.S. Federal Aviation Regulations, Paragraph 25.775, "Part 25 - Airworthiness Standards: Transport Category Airplanes."

10) U.S. Federal Aviation Regulations, Paragraph 91.117, "Part 91 - General Operating and Flight Rules."

11) McLellan G.W. and Shand, E.B., *Glass Engineering Handbook*, McGraw-Hill, New York, 1984, pp. 6-4.

12) Phillips, C.J., *Glass, Its Industrial Applications*, Reinhold Publishing Corporation, New York, 1960, pp. 82-85.

13) Greene, C.H., *Modern Glass Practice*, Cahners Books, Boston, 1975, pp.358-359.

14) Weidehorn, S.M., and Bolz, L.H., "Stress Corrosion and Static Fatigue of Glass," *Journal of the American Ceramic Society*, Vol 53, 1970, pp. 543-548.

15) Freiman, S.W., "Effects of Chemical Environment on Slow Crack Growth in Glasses and Ceramics," *Journal of Geophysical Research*, Vol 89, 1984, pp.4072-4076.

16) Stanworth, J.E., *Physical Properties of Glass*, Oxford Press, London, 1950, pp. 100-101.

17) McLellan G.W. and Shand, E.B., *Glass Engineering Handbook*, McGraw-Hill, New York, 1984, pp. 6-4 to 6-6.

Table 2.1 C/KC-135 W/WS Part Numbers

Type of Windshield	NSN	Part Number
#1 Pilot	1560-01-048-1885 FL	5-89354-501
#1 Copilot	1560-01-048-1786 FL	5-89354-502
#2 Pilot	1560-01-009-3320 FL	5-89355-501
#2 Copilot	1560-01-008-7396 FL	5-89355-502
#3 Pilot	1560-00-575-6302 FL	5-89356-501
#3 Copilot	1560-00-575-6297 FL	5-89356-502
#4 Pilot	1560-00-575-6299 FL	5-71764-501
#4 Copilot	1560-00-575-6298 FL	5-71764-502
#5 Pilot	1560-00-575-6300 FL	5-89358-501
#5 Copilot	1560-00-575-6301 FL	5-89358-502

Table 2.2 C/KC-135 Program W/WS

Type of Windshield (1-5)	S/N	Condition
1	82-H-9-6-537	repairable
1	84-H-3-19-220	repairable
1	1-H-10-5-480	repairable
1	83-H-9-19-294	**not repairable**
1	83-H-9-19-282	repairable
1	83-H-8-15-756	repairable
1	82-H-10-18-107	repairable
1	83-H-11-7-432	repairable
1	82-H-9-6-235	repairable
1	83-H-11-21-325	repairable
1	86-H-12-01-146	repairable
1	88-H-02-08-436	repairable
1	6-H-8-4-26	repairable
1	89-286-HO-697	repairable
1	82-H-10-105	repairable
1	83-H-9-19-459	repairable
1	82-H-12-6-431	repairable

Table 2.2 C/KC-135 Program W/WS continued

Type of Windshield (1-5)	S/N	Condition
2	4-H-9-27-168	repairable
2	6-H-1-15-28	repairable
2	85-H-06-03-722	repairable
2	6-H-2-27-57	not repairable
2	6-H-2-20-23	not repairable
3	5-H-3-2-730	not repairable
3	6-H-3-18-28	not repairable
3	6-H-4-6-25	not repairable
3	6-H-12-10-30	not repairable
3	B73-2815	not repairable
3	B73-3439	not repairable
3	B73-3565	not repairable
3	B73-2462	not repairable
3	85-H-01-07-725	not repairable
3	0-H-9-1-1140	not repairable
3	B73-2509	not repairable
3	5-H-2-16-042	not repairable
3	B73-3955	not repairable
3	4-H-10-4-02	not repairable
3	4-H-9-18-15	not repairable
3	7-H-12-13-67	not repairable

Table 2.2 **C/KC-135 Program W/WS** continued

Type of Windshield (1-5)	S/N	Condition
4	4-H-10-15-108	**not repairable**
4	4-H-10-9-75	**not repairable**
4	4-H-9-28-87	repairable
4	5-H-12-16-47	repairable
4	6-H-4-29-50	**not repairable**
4	8-H-2-06-585	repairable
4	87-H-04-20-130	repairable
4	7-H-1-25-01	**not repairable**
4	3-H-4-26-45	repairable
4	82-H-12-6-392	**not repairable**
4	B75-1149	repairable
4	6-H-12-02-36	**not repairable**
4	85-H-07-01-276	repairable
4	7-H-2-4-35	**not repairable**
4	90-173-HO-721	repairable
4	4-H-10-9-69	**not repairable**
4	4-C-02-12-10	**not repairable**
4	84-H-10-15-1225	repairable
4	85-H-07-01-366	repairable
4	85-H-09-02-795	**not repairable**
4	5-H-5-23-84	**not repairable**

Table 2.2 **C/KC-135 Program W/WS** continued

Type of Windshield (1-5)	S/N	Condition
5	4-C-5-16-11	**not repairable**
5	4-C-5-28-16	**not repairable**
5	4-H-8-30-95	repairable
5	5-H-2-5-75	**not repairable**
5	2-H-12-15-58	**not repairable**
5	H-30-67	**not repairable**
5	7-H-10-14-56	repairable
5	2-H-6-20-70	**not repairable**
5	2-H-4-24-49	**not repairable**
5	4-C-7-12-22	repairable
5	4-H-8-33-64	**not repairable**
5	5-H-12-5-05	repairable
5	4-C-6-12-13	**not repairable**
5	2-H-6-29-06	**not repairable**
5	3-H-5-23-79	repairable

Table 2.3 C/KC-135 #1 and #4 W/WS Dimensions

	#1 W/S	#4 W/S
Length (approx), inches	35	13
Height (approx), inches	18	10
Thickness (approx), inches	1	1
Weight (approx), pounds	46	8

Table 3.1 C/KC-135 Repaired and Not Repaired #1 W/WS in the Test Program

S/N	Repair Vendor	Vendor Damage Comments	Vendor Repair Comments
83-H-11-7-432	Perkins	delaminated	
82-H-10-18-105	Perkins	delaminated, scratched	
88-H-02-08-436	NORDAM	scratches	polish, replace bumper and pressure seal
82-H-12-6-431	NORDAM	scratches and chips	polish, replace bumper and pressure seal
1-H-10-5-480	Perkins	delaminated, scratched	
83-H-9-19-294	Perkins	delaminated	**not repairable**
82-H-9-6-537	NORDAM	scratches	polish, replace bumper and pressure seal
83-H-9-19-459	NORDAM	scratches and chips	polish, replace bumper and pressure seal
83-H-9-19-282	Perkins	delaminated	
83-H-8-15-756	Perkins	delaminated	
84-H-3-19-220	Perkins	delaminated, scratched	
86-H-12-01-146	NORDAM	scratches and chips	polish, replace bumper and pressure seal
82-H-10-18-107	Perkins	delaminated	
82-H-9-6-235	NORDAM	scratches	polish, replace bumper and pressure seal
83-H-11-21-325	NORDAM	scratches and chips	polish, replace bumper and pressure seal
89-286-HO-697	NORDAM	scratches	polish, replace bumper and pressure seal

Table 3.2 C/KC-135 Repaired and Not Repaired #4 W/WS in the Test Program

S/N	Repair Vendor	Vendor Damage Comments	Repair Comments
B75-1149	NORDAM	scratches	polish, replace bumper and pressure seals
85-H-07-01-276	NORDAM	scratches	polish, replace bumper and pressure seals
90-173-HO-721	Perkins	bad terminal block	
5-H-5-23-84	NORDAM	delamination, scratches, bad resistance	**not repairable**
7-H-2-4-35	NORDAM	scratches, bad resistance	**not repairable**
4-H-10-9-69	Perkins	contaminated	**not repairable**
82-H-12-6-392	Perkins	contaminated	**not repairable**
6-H-12-02-36	Perkins	bad resistance	**not repairable**
87-H-04-20-130	NORDAM	scratches	polish, replace bumper and pressure seals
8-H-2-06-585	Perkins	delamination, scratches	
85-H-07-01-366	NORDAM	scratches	polish, replace bumper and pressure seals
5-H-12-16-47	NORDAM	delamination, scratches	polish, autoclave, replace bumper and pressure seals
84-H-10-15-1225	NORDAM	delamination, scratches	polish, autoclave, replace bumper and pressure seals
4-H-9-28-87	NORDAM	scratches	polish, replace bumper and pressure seals
3-H-4-26-45	NORDAM	delamination, scratches, and chips	polish, autoclave, replace bumper and pressure seals
4-H-10-15-108	NORDAM	delamination, scratches, bad resistance	**not repairable**

Table 4.1 C/KC-135 #1 W/WS General Examination and Dimensional Measurements Test Results (acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
86-H-10-06-062	new	acc	acc	acc	acc	
86-H-10-06-092	new	acc	acc	acc	acc	
86-H-10-06-013	new	acc	acc	acc	acc	
86-H-10-06-048	new	acc	acc	acc	acc	
83-H-11-7-432	repaired	**REJ**	**REJ**	acc	acc	1,a
82-H-10-18-105	repaired	**REJ**	**REJ**	acc	acc	1,2,b
88-H-02-08-436	repaired	**REJ**	**REJ**	acc	acc	1,b
82-H-12-6-431	repaired	**REJ**	acc	acc	acc	1
1-H-10-5-480	repaired	**REJ**	**REJ**	acc	acc	1,c
83-H-9-19-294	not repaired	**REJ**	**REJ**	**REJ**	acc	1,2,d
82-H-9-6-537	repaired	**REJ**	**REJ**	acc	acc	1,c
83-H-9-19-459	repaired	**REJ**	**REJ**	acc	acc	1,2,b

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.1 C/KC-135 #1 W/WS General Examination and Dimensional Measurements Test Results continued (acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
86-H-10-06-007	new	acc	acc	acc	acc	
86-H-10-06-030	new	acc	acc	acc	acc	
86-H-10-06-022	new	acc	acc	acc	acc	
86-H-10-06-096	new	acc	acc	acc	acc	
83-H-9-19-282	repaired	**REJ**	**REJ**	acc	acc	3,c
83-H-8-15-756	repaired	acc	**REJ**	acc	acc	c
84-H-3-19-220	repaired	**REJ**	**REJ**	acc	acc	4,b
86-H-12-01-146	repaired	acc	**REJ**	acc	acc	c
82-H-10-18-107	repaired	**REJ**	**REJ**	acc	acc	5,b
82-H-9-6-235	repaired	**REJ**	**REJ**	acc	acc	1,2,6,b
83-H-11-21-325	repaired	**REJ**	**REJ**	acc	acc	1,b
89-286-HO-697	repaired	**REJ**	**REJ**	acc	acc	2,b

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.2 C/KC-135 #4 W/WS General Examination and Dimensional Measurements Test Results (acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
B75-1149	repaired	**REJ**	**REJ**	acc	acc	3,c
92-064-HO-471	new	acc	acc	acc	acc	
92-064-HO-473	new	acc	acc	acc	acc	
92-059-HO-350	new	acc	acc	acc	acc	
92-025-HO-006	new	acc	acc	acc	acc	
92-119-HO-186	new	acc	acc	acc	acc	
85-H-07-01-276	repaired	**REJ**	**REJ**	acc	no data	1,c
90-173-HO-721	repaired	acc	**REJ**	acc	acc	c
5-H-5-23-84	not repaired	**REJ**	**REJ**	**REJ**	acc	1,2,e,f
7-H-2-4-35	not repaired	**REJ**	**REJ**	no data	acc	1,2,f
4-H-10-9-69	not repaired	**REJ**	**REJ**	**REJ**	acc	1,g,h
82-H-12-6-392	not repaired	**REJ**	**REJ**	**REJ**	acc	1,g,h
6-H-12-02-36	not repaired	**REJ**	**REJ**	acc	acc	1,h

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.2 C/KC-135 #4 W/WS General Examination and Dimensional Measurements Test Results continued (acc=acceptable, REJ=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
87-H-04-20-130	repaired	**REJ**	**REJ**	acc	acc	6,c
8-H-2-06-585	repaired	**REJ**	**REJ**	acc	no data	1,c,i
85-H-07-01-366	repaired	**REJ**	**REJ**	acc	acc	1,c,f
92-064-HO-470	new	acc	acc	acc	acc	
92-098-HO-591	new	acc	acc	acc	acc	
92-093-HO-392	new	acc	acc	acc	acc	
92-093-HO-388	new	acc	acc	acc	acc	
5-H-12-16-47	repaired	**REJ**	**REJ**	acc	acc	1,c
84-H-10-15-1225	repaired	**REJ**	**REJ**	**REJ**	acc	1,2,c
4-H-9-28-87	repaired	**REJ**	acc	acc	acc	1
3-H-4-26-45	repaired	**REJ**	**REJ**	**REJ**	acc	1,2,f,g
4-H-10-15-108	not repaired	**REJ**	**REJ**	**REJ**	acc	1,2,

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.3 C/KC-135 #1 W/WS Basic Electrical Measurements Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Bus Resistance	Sensor Resistance	Insulation Integrity		
				bus-to-sensor	sensor-to-frame	sensor-to-sensor
86-H-10-06-062	new	acc	acc	acc	acc	acc
86-H-10-06-092	new	acc	acc	acc	acc	acc
86-H-10-06-013	new	acc	acc	acc	acc	acc
86-H-10-06-048	new	acc	acc	acc	acc	acc
83-H-11-7-432	repaired	acc	acc	acc	acc	acc
82-H-10-18-105	repaired	acc	acc	acc	acc	**REJ**
88-H-02-08-436	repaired	acc	acc	acc	acc	**REJ**
82-H-12-6-431	repaired	acc	acc	acc	acc	acc
1-H-10-5-480	repaired	acc	acc	acc	acc	acc
83-H-9-19-294	not repaired	acc	acc	acc	acc	**REJ**
82-H-9-6-537	repaired	acc	acc	acc	acc	**REJ**
83-H-9-19-459	repaired	acc	acc	acc	acc	**REJ**
86-H-10-06-007	new	acc	acc	acc	acc	acc
86-H-10-06-030	new	acc	acc	acc	acc	acc
86-H-10-06-022	new	acc	acc	acc	acc	acc
86-H-10-06-096	new	acc	acc	acc	acc	acc
83-H-9-19-282	repaired	acc	acc	acc	acc	acc
83-H-8-15-756	repaired	acc	acc	acc	acc	acc
84-H-3-19-220	repaired	acc	acc	acc	acc	**REJ**
86-H-12-01-146	repaired	acc	acc	acc	acc	acc
82-H-10-18-107	repaired	acc	acc	acc	acc	**REJ**
82-H-9-6-235	repaired	acc	acc	acc	acc	**REJ**
83-H-11-21-325	repaired	acc	acc	acc	acc	**REJ**
89-286-HO-697	repaired	acc	acc	acc	acc	**REJ**

Table 4.4 C/KC-135 #4 W/WS Basic Electrical Measurements Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Bus Resistance	Insulation Integrity
			bus-to-frame
B75-1149	repaired	acc	acc
92-064-HO-471	new	acc	acc
92-064-HO-473	new	acc	acc
92-059-HO-350	new	acc	acc
92-025-HO-006	new	acc	acc
92-119-HO-186	new	acc	acc
85-H-07-01-276	repaired	**REJ**	no data
90-173-HO-721	repaired	**REJ**	acc
5-H-5-23-84	not repaired	**REJ**	acc
7-H-2-4-35	not repaired	**REJ**	acc
4-H-10-9-69	not repaired	acc	acc
82-H-12-6-392	not repaired	acc	acc
6-H-12-02-36	not repaired	acc	acc
87-H-04-20-130	repaired	acc	acc
8-H-2-06-585	repaired	acc	acc
85-H-07-01-366	repaired	acc	acc
92-064-HO-470	new	acc	acc
92-098-HO-591	new	acc	acc
92-093-HO-392	new	acc	acc
92-093-HO-388	new	acc	acc
5-H-12-16-47	repaired	**REJ**	acc
84-H-10-15-1225	repaired	acc	acc
4-H-9-28-87	repaired	acc	acc
3-H-4-26-45	repaired	acc	acc
4-H-10-15-108	not repaired	**REJ**	acc

Table 4.5 C/KC-135 #1 W/WS Heater Operation Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Heater Operation	Hot/Cold Spots	Heater Film Scratch Test
86-H-10-06-062	new	90-110° F	no	acc
86-H-10-06-092	new	90-115° F	no	acc
86-H-10-06-013	new	90-110° F	no	acc
86-H-10-06-048	new	90-110° F	no	acc
83-H-11-7-432	repaired	85-115° F	no	acc
82-H-10-18-105	repaired	85-110° F	no	acc
88-H-02-08-436	repaired	90-110° F	no	acc
82-H-12-6-431	repaired	95-120° F	no	acc
1-H-10-5-480	repaired	90-115° F	no	acc
83-H-9-19-294	not repaired	no test	-	acc
82-H-9-6-537	repaired	80-140° F	no	acc
83-H-9-19-459	repaired	90-110° F	no	acc
86-H-10-06-007	new	90-115° F	no	acc
86-H-10-06-030	new	90-115° F	no	acc
86-H-10-06-022	new	missing photo	-	acc
86-H-10-06-096	new	90-110° F	no	acc
83-H-9-19-282	repaired	90-115° F	no	acc
83-H-8-15-756	repaired	90-115° F	no	acc
84-H-3-19-220	repaired	90-110° F	no	acc
86-H-12-01-146	repaired	95-120° F	no	acc
82-H-10-18-107	repaired	90-115° F	no	acc
82-H-9-6-235	repaired	90-115° F	no	acc
83-H-11-21-325	repaired	90-115° F	no	acc
89-286-HO-697	repaired	90-115° F	no	acc

Table 4.6 C/KC-135 #4 W/WS Heater Operation Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Heater Operation	Hot/Cold Spots	Heater Film Scratch Test
B75-1149	repaired	95-115° F	no	acc
92-064-HO-471	new	95-110° F	no	acc
92-064-HO-473	new	95-120° F	no	acc
92-059-HO-350	new	95-110° F	no	acc
92-025-HO-006	new	95-110° F	no	acc
92-119-HO-186	new	missing photo	-	acc
85-H-07-01-276	repaired	no test	-	**REJ**
90-173-HO-721	repaired	no test	-	acc
5-H-5-23-84	not repaired	95-115° F	no	acc
7-H-2-4-35	not repaired	95-115° F	no	acc
4-H-10-9-69	not repaired	95-110° F	no	acc
82-H-12-6-392	not repaired	95-115° F	no	acc
6-H-12-02-36	not repaired	95-110° F	no	acc
87-H-04-20-130	repaired	95-110° F	no	acc
8-H-2-06-585	repaired	95-110° F	no	acc
85-H-07-01-366	repaired	missing photo	-	acc
92-064-HO-470	new	95-110° F	no	acc
92-098-HO-591	new	95-115° F	no	acc
92-093-HO-392	new	95-135° F	no	acc
92-093-HO-388	new	95-110° F	no	acc
5-H-12-16-47	repaired	95-110° F	no	acc
84-H-10-15-1225	repaired	95-110° F	no	acc
4-H-9-28-87	repaired	95-110° F	no	acc
3-H-4-26-45	repaired	95-110° F	no	acc
4-H-10-15-108	not repaired	95-115° F	no	acc

Table 4.7 C/KC-135 #1 W/WS Optical Performance Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Luminous Transmittance	Haze	Deviation	Distortion, center/edge
86-H-10-06-062	new	acc	acc	acc	none/1:30
86-H-10-06-092	new	acc	acc	acc	none/none
86-H-10-06-013	new	acc	acc	acc	none/none
86-H-10-06-048	new	acc	acc	acc	none/none
83-H-11-7-432	repaired	acc	acc	acc	none/1:20
82-H-10-18-105	repaired	acc	acc	acc	none/none
88-H-02-08-436	repaired	acc	acc	acc	none/none
82-H-12-6-431	repaired	acc	acc	acc	none/none
1-H-10-5-480	repaired	acc	acc	acc	none/none
83-H-9-19-294	not repaired	acc	acc	acc	none/none
82-H-9-6-537	repaired	acc	acc	acc	none/none
83-H-9-19-459	repaired	acc	acc	acc	none/none
86-H-10-06-007	new	acc	acc	acc	none/none
86-H-10-06-030	new	acc	acc	acc	none/none
86-H-10-06-022	new	acc	acc	acc	none/none
86-H-10-06-096	new	acc	acc	acc	none/none
83-H-9-19-282	repaired	acc	acc	acc	none/none
83-H-8-15-756	repaired	acc	acc	acc	none/none
84-H-3-19-220	repaired	acc	acc	acc	none/none
86-H-12-01-146	repaired	acc	acc	acc	none/1:30
82-H-10-18-107	repaired	acc	acc	acc	none/1:40
82-H-9-6-235	repaired	acc	acc	acc	none/none
83-H-11-21-325	repaired	acc	acc	acc	none/none
89-286-HO-697	repaired	acc	acc	acc	none/none

Table 4.8 C/KC-135 #4 W/WS Optical Performance Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Luminous Transmittance	Haze	Deviation	Distortion, center/edge
B75-1149	repaired	acc	acc	acc	none/1:18
92-064-HO-471	new	acc	acc	acc	none/1:11
92-064-HO-473	new	acc	acc	acc	none/1:14
92-059-HO-350	new	acc	acc	acc	none/1:7
92-025-HO-006	new	acc	acc	acc	none/1:8
92-119-HO-186	new	acc	acc	acc	missing photo
85-H-07-01-276	repaired	acc	acc	acc	none/1:12
90-173-HO-721	repaired	acc	acc	acc	none/1:10
5-H-5-23-84	not repaired	acc	acc	acc	none/none
7-H-2-4-35	not repaired	acc	acc	acc	none/1:25
4-H-10-9-69	not repaired	acc	acc	acc	none/1:21
82-H-12-6-392	not repaired	acc	acc	acc	none/1:7
6-H-12-02-36	not repaired	acc	acc	acc	none/none
87-H-04-20-130	repaired	acc	acc	acc	1:16/1:5
8-H-2-06-585	repaired	acc	acc	acc	none/1:22
85-H-07-01-366	repaired	acc	acc	acc	none/1:8
92-064-HO-470	new	acc	acc	acc	none/1:12
92-098-HO-591	new	acc	acc	acc	none/1:9
92-093-HO-392	new	acc	acc	acc	none/1:10
92-093-HO-388	new	acc	acc	acc	none/1:9
5-H-12-16-47	repaired	acc	acc	acc	none/none
84-H-10-15-1225	repaired	acc	acc	acc	none/1:6
4-H-9-28-87	repaired	acc	acc	acc	none/1:16
3-H-4-26-45	repaired	acc	acc	acc	none/none
4-H-10-15-108	not repaired	acc	acc	acc	1:16/1:22

Table 4.9 C/KC-135 #1 W/WS Pressure Integrity Test Results

S/N	Type	Initial Proof Pressure Test	Damage from Pressure Cycling	Final Proof Pressure Test
86-H-10-06-062	new	passed	no apparent damage	passed
86-H-10-06-092	new	passed	no apparent damage	passed
86-H-10-06-013	new	passed	no apparent damage	passed
86-H-10-06-048	new	passed	no apparent damage	passed
83-H-11-7-432	repaired	passed	no apparent damage	passed
81-H-10-18-105	repaired	passed	no apparent damage	passed
88-H-02-08-436	repaired	passed	no apparent damage	passed
82-H-12-6-431	repaired	passed	no apparent damage	passed
1-H-10-5-480	repaired	passed	no apparent damage	passed
83-H-9-19-294	not repaired	passed	no apparent damage	passed
82-H-9-6-537	repaired	passed	delamination near slip plane areas	passed
83-H-9-19-459	repaired	passed	delamination near slip plane areas	passed

Table 4.10 C/KC-135 #4 W/WS Pressure Integrity Test Results

S/N	Type	Initial Proof Pressure Test	Damage from Pressure Cycling	Final Proof Pressure Test
87-H-04-20-130	repaired	passed	no apparent damage	passed
8-H-2-06-585	repaired	passed	no apparent damage	passed
85-H-07-01-366	repaired	passed	no apparent damage	passed
92-064-HO-470	new	passed	no apparent damage	passed
92-098-HO-591	new	passed	no apparent damage	passed
92-093-HO-392	new	passed	no apparent damage	passed
92-093-HO-388	new	passed	no apparent damage	passed
5-H-12-16-47	repaired	passed	large amount of delamination along forward edge and lower forward corner	passed
84-H-10-15-1225	repaired	passed	no apparent damage	passed
4-H-9-28-87	repaired	passed	no apparent damage	passed
3-H-4-26-45	repaired	passed	delamination in lower forward corner of less than 1 square inch	passed
4-H-10-15-108	not repaired	passed	no apparent damage	passed

Table 4.11 C/KC-135 #1 W/WS Residual Strength Ball Drop Test Results

W/WS S/N	Type	Damage from Pressure Cycling	Comments
86-H-10-06-062	new	no apparent damage	Two ball drops. Outboard glass ply broken. Crushing in impact area. No delamination created by cracking of the outer ply.
83-H-9-19-459	repaired	delamination near slip plane areas	Two ball drops. Outboard glass ply broken. Core ply intact. No delamination from glass breakage.
1-H-10-5-480	repaired	no apparent damage	Two ball drops. Outboard glass ply broken. No delamination from outer ply cracking.
81-H-10-18-105	repaired	no apparent damage	One ball drop only. Both glass plies failed. Large amount of spall driven from core ply inboard surface.
82-H-9-6-537	repaired	delamination near slip plane areas	One ball drop only. Both glass plies failed. Large amount of spall removed from core ply surface.

Table 4.12 C/KC-135 #4 W/WS Residual Strength Ball Drop Test Results

W/WS S/N	Type	Damage from Pressure Cycling	Comments
92-093-HO-388	new	no apparent damage	Outboard glass ply broken. Core ply intact. No delamination associated with glass breaking.
87-H-04-20-130	repaired	no apparent damage	Outboard glass ply broken. Core ply intact. No delamination associated with glass breaking.
8-H-2-06-585	repaired	no apparent damage	Outboard glass ply broken. Core ply intact. No delamination associated with glass breaking.
3-H-4-26-45	repaired	delamination in lower forward corner of less than 1 square inch	Both glass plies failed. Large area of core ply inboard surface spalled in impact area.
5-H-12-16-47	repaired	large amount of delamination along forward edge and lower forward corner	Both glass plies failed. Large area of core ply inboard surface spalled in impact area.

Table 4.13 C/KC-135 #1 W/WS Bird Impact Test Results

Date	Shot Number	S/N	Type	Impact Velocity (knots)	Comments
6/22/93	783	86-H-10-06-007	new	251.7	Outboard glass ply broken. Core ply intact. Small amount of bird residue impacted spall sheet - entry between outboard glass ply and W/WS frame when mounting O-rings compressed.
6/22/93	784	86-H-10-06-030	new	251.1	No damage. Small amount of bird residue on spall sheet, same as Shot 783.
6/23/93	785	86-H-10-06-22	new	252.8	No damage. No bird residue on spall sheet.
6/23/93	786	86-H-10-06-96	new	252.6	No damage. No bird residue on spall sheet.
6/24/93	792	83-H-9-19-2-282	repaired	249.6	Outboard ply intact. Core ply failed. No glass spall on spall sheet.
7/19/93	793	83-H-8-15-756	repaired	249.4	All glass plies failed. Minor glass spall on spall sheet.
7/19/93	794	84-H-3-19-220	repaired	250.1	Outboard glass ply failed. Core ply intact.
7/20/93	795	86-H-12-01-146	repaired	252.4	No glass breakage. Z-bar retainer bent badly.
7/20/93	796	82-H-10-18-107	repaired	249.4	All glass plies failed. Minor amount of glass spall from inboard ply on spall sheet.
7/20/93	797	82-H-9-6-235	repaired	251.0	Outboard glass ply failed. Core ply intact.
7/21/93	798	83-H-11-21-325	repaired	247.5	All glass plies failed. No spall on spall sheet.
7/22/93	799	89-286-HO-697	repaired	250.8	No damage.

Table 4.14 C/KC-135 #4 W/WS Bird Impact Test Results

Date	Shot Number	S/N	Type	Impact Velocity (knots)	Comments
9/1/93	815	B75-1149	repaired	247.5	Outboard glass ply failed. Bird residue between outboard retainer gasket along aft edge and top right corner. Bent bolts.
9/1/93	816	92-064-HO-471	new	251.3	No damage. Small amount of bird residue between outboard retainer and W/WS. No bent bolts.
9/1/93	817	92-064-HO-473	new	248.9	No damage. Minor bird residue through aft edge.
9/1/93	818	92-059-HO-350	new	225.1	Bird cannon misfire due to camera failure. Inboard glass ply chipped.
9/29/93	835	92-025-HO-006	new	248.4	No damage.
9/29/93	836	92-119-HO-186	new	247.8	No damage.
9/29/93	837	85-H-07-01-276	repaired	248.7	No damage.
9/29/93	838	90-173-HO-721	repaired	247.1	No damage.
9/30/93	839	5-H-5-23-84	not repaired	251.2	Outboard ply broken. No bird penetration. Interlayer tear in lower forward corner.
9/30/93	840	7-H-2-4-35	not repaired	250.8	Catastrophic failure. Entire laminated panel torn out at insert.
9/30/93	841	4-H-10-9-69	not repaired	251.0	No damage.
9/30/93	842	82-H-12-6-392	not repaired	250.8	No damage.
10/1/93	843	6-H-12-02-36	not repaired	250.3	All glass plys failed. 4-inch long interlayer tear at lower forward corner. Some glass spall.

Table 4.15 C/KC-135 W/WS General Inspection Summary

	#1 W/WS			#4 W/WS		
Category	New	Repaired	Not Repaired	New	Repaired	Not Repaired
Number Tested	8	15	1	9	10	6
Number with delamination, scratches, or chips	0	13	1	0	9	6
Number with seal deficiencies	0	14	1	0	8	6
Number with vinyl cracks	0	0	1	0	2	4
Number with bad dimensional check	0	0	0	0	0	0
Number with bad bus resistance	0	0	0	0	3	3
Number with bad sensor resistance	0	0	0	–	–	–
Number with bad insulation	0	9	1	0	0	0
Number with poor heater performance	0	0	1	0	1	0
Number with bad optics	0	0	0	0	0	0

Table 4.16 C/KC-135 W/WS Pressure Integrity Test Summary

	#1 W/WS			#4 W/WS		
Category	New	Repaired	Not Repaired	New	Repaired	Not Repaired
Number Tested	4	7	1	4	7	1
Number failing initial proof pressure test	0	0	0	0	0	0
Number failing during pressure cycling	0	0	0	0	0	0
Number failing final proof pressure test	0	0	0	0	0	0
Number delaminated	0	2	0	0	2	0

Table 4.17 C/KC-135 W/WS Ball Drop Residual Strength Test Summary

	#1 W/WS		#4 W/WS	
Category	New	Repaired	New	Repaired
Number Tested	1	4	1	4
Number with initial delamination	0	2	0	2
Number with outboard ply failure only	1	2	1	2
Number with both glass plys failed	0	2	0	2

Table 4.18 C/KC-135 W/WS Bird Impact Test Summary

	#1 W/WS		#4 W/WS		
Category	New	Repaired	New	Repaired	Not Repaired
Number Tested	4	8	5	3	5
Number undamaged	3	2	4	2	2
Number with outboard ply broken only	1	2	1	1	1
Number with inboard ply broken only	0	1	0	0	0
Number with all glass plies failed	0	3	0	0	2
Number with no inner ply glass spall	4	6	5	3	3
Number with minor inner ply glass spall	0	2	0	0	1
Number with major inner ply glass spall	0	0	0	0	1
Number with no bird penetration	4	8	5	3	4
Number with minor bird penetration	0	0	0	0	0
Number with major bird penetration	0	0	0	0	1

Table 4.19 C/KC-135 #1 W/WS Mounting Edge Measurements and Bird Impact Test Results

S/N	Type	Edge Thickness, inches	Bird Impact Comments
86-H-10-06-007	new	0.936 0.943 0.942	Outboard glass ply broken. Core ply intact.
82-H-10-18-107	repaired	0.843 0.852 0.838	All glass plies failed. Minor amount of glass spall from inboard ply on spall sheet.
83-H-9-19-282	repaired	similar to 82-H-10-18-107	Core ply failed. No glass spall on spall sheet.
83-H-8-15-756	repaired	similar to 82-H-10-18-107	All glass plies failed. Minor glass spall on spall sheet.
83-H-11-21-325	repaired	0.927 0.936 0.939	All glass plies failed. No spall on spall sheet.
86-H-06-030 86-H-10-06-22 86-H-10-06-96	new	0.908 min 0.940 max	No damage.
84-H-3-19-220	repaired		Outboard glass ply failed.
86-H-12-01-146			No glass breakage.
82-H-9-6-235			Outboard glass ply failed.
89-286-HO-697			No damage.
91-010-HO-206	unrepaired	0.850 min 0.909 max	Not bird impact tested.
87-H-06-29-758		0.893 min 0.920 max	
87-H-09-21-671		0.886 min 0.922 max	
90-180-HO-139		0.839 min 0.887 max	
82-H-9-20-127		0.902 min 0.918 max	

Table 5.1 Initial C/KC-135 W/WS Repair Estimates

Type of W/WS		NORDAM[a]	Perkins[b]	The Glass Doctor[b]
1		$1,890	$2,000	$1,327[c]
2	glass only	$1,512	$1,500	$896
	frame and glass	$6,700	-	-
3		$735 Category I[d] $945 Category II $945 Category III $1,280 Category IV	$750	$516
4		$975	$875	$667
5		$750	$875	$484

Notes:

a) Estimate, actual price quote based on specific repairs required as determined by incoming inspection.
b) Fixed price.
c) Sensor repair or replacement, $437 additional.
d) NORDAM #3 W/WS Repair/Overhaul Categories:

All repair categories include complete disassembly, inspection, and reassembly with new seal and new grommets.

Category	Transparency Repair
I	Polish inner and outer panes
II	Polish outer pane, replace inner pane
III	Polish inner pane, replace outer pane
IV	Replace inner and outer panes

Table 5.2 C/KC-135 #1 W/WS Actual Repair Costs (NR=not repairable)

S/N	Repair Vendor	Vendor Damage Comments	Repair Cost
83-H-11-7-432	Perkins	delaminated	$2,000
82-H-10-18-105	Perkins	delaminated, scratched	$2,000
88-H-02-08-436	NORDAM	scratches	$1,695
82-H-12-6-431	NORDAM	scratches and chips	$2,090
1-H-10-5-480	Perkins	delaminated, scratched	$2,000
83-H-9-19-294	Perkins	delaminated	$0, **NR**
82-H-9-6-537	NORDAM	scratches	$1,893
83-H-9-19-459	NORDAM	scratches and chips	$1,893
83-H-9-19-282	Perkins	delaminated	$2,000
83-H-8-15-756	Perkins	delaminated	$2,000
84-H-3-19-220	Perkins	delaminated, scratched	$2,000
86-H-12-01-146	NORDAM	scratches and chips	$1,695
82-H-10-18-107	Perkins	delaminated	$2,000
82-H-9-6-235	NORDAM	scratches	$1,695
83-H-11-21-325	NORDAM	scratches and chips	$2,090
89-286-HO-697	NORDAM	scratches	$2,090

Table 5.3 C/KC-135 #4 W/WS Actual Repair Costs (NR=not repairable)

S/N	Repair Vendor	Vendor Damage Comments	Repair Cost
B75-1149	NORDAM	scratches	$559
85-H-07-01-276	NORDAM	scratches	$954
90-173-HO-721	Perkins	bad terminal block	$875
5-H-5-23-84	NORDAM	delamination, scratches, bad resistance	$0, **NR**
7-H-2-4-35	NORDAM	scratches, bad resistance	$0, **NR**
4-H-10-9-69	Perkins	contaminated	$0, **NR**
82-H-12-6-392	Perkins	contaminated	$0, **NR**
6-H-12-02-36	Perkins	bad resistance	$0, **NR**
87-H-04-20-130	NORDAM	scratches	$954
8-H-2-06-585	Perkins	delamination, scratches	$875
85-H-07-01-366	NORDAM	scratches	$559
5-H-12-16-47	NORDAM	delamination, scratches	$1,151
84-H-10-15-1225	NORDAM	delamination, scratches	$1,151
4-H-9-28-87	NORDAM	scratches	$559
3-H-4-26-45	NORDAM	delamination, scratches, and chips	$1,349
4-H-10-15-108	NORDAM	delamination, scratches, bad resistance	$0, **NR**

Table 5.4 Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS (NR=not repairable)

Type of W/WS (1-5)	S/N	Repair Vendor	Cost of Repair
1	82-H-9-6-537	NORDAM	$1,893
1	84-H-3-19-220	Perkins	$2,000
1	1-H-10-5-480	Perkins	$2,000
1	83-H-9-19-294	Perkins	$0, **NR**
1	83-H-9-19-282	Perkins	$2,000
1	83-H-8-15-756	Perkins	$2,000
1	82-H-10-18-107	Perkins	$2,000
1	83-H-11-7-432	Perkins	$2,000
1	82-H-9-6-235	NORDAM	$1,695
1	83-H-11-21-325	NORDAM	$2,090
1	86-H-12-01-146	NORDAM	$2,090
1	88-H-02-08-436	NORDAM	$1,695
1	6-H-8-4-26	NORDAM	$2,683
1	89-286-HO-697	NORDAM	$2,090
1	82-H-10-105	Perkins	$2,000
1	83-H-9-19-459	NORDAM	$1,893
1	82-H-12-6-431	NORDAM	$2,090
2	4-H-9-27-168	NORDAM	$1,919
2	6-H-1-15-28	NORDAM	$1,524
2	85-H-06-03-722	NORDAM	$1,721
2	6-H-2-27-57	Perkins	$0, **NR**
2	6-H-2-20-23	Perkins	$0, **NR**
3	5-H-3-2-730	NORDAM	$0, **NR**
3	6-H-3-18-28	NORDAM	$0, **NR**
3	6-H-4-6-25	NORDAM	$0, **NR**
3	6-H-12-10-30	NORDAM	$0, **NR**
3	B73-2815	Perkins	$0, **NR**
3	B73-3439	Perkins	$0, **NR**

Table 5.4 **Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS** continued (**NR**=not repairable)

Type of W/WS (1-5)	S/N	Repair Vendor	Cost of Repair
3	B73-3565	Perkins	$0, **NR**
3	B73-2462	NORDAM	$0, **NR**
3	85-H-01-07-725	Perkins	$0, **NR**
3	0-H-9-1-1140	NORDAM	$0, **NR**
3	B73-2509	Perkins	$0, **NR**
3	5-H-2-16-042	NORDAM	$0, **NR**
3	B73-3955	Perkins	$0, **NR**
3	4-H-10-4-02	Perkins	$0, **NR**
3	4-H-9-18-15	Perkins	$0, **NR**
3	7-H-12-13-67	NORDAM	$0, **NR**
4	4-H-10-15-108	NORDAM	$0, **NR**
4	4-H-10-9-75	Perkins	$0, **NR**
4	4-H-9-28-87	NORDAM	$559
4	5-H-12-16-47	NORDAM	$1,151
4	6-H-4-29-50	Perkins	$0, **NR**
4	8-H-2-06-585	Perkins	$875
4	87-H-04-20-130	NORDAM	$954
4	7-H-1-25-01	Perkins	$0, **NR**
4	3-H-4-26-45	NORDAM	$1,349
4	82-H-12-6-392	Perkins	$0, **NR**
4	B75-1149	NORDAM	$559
4	6-H-12-02-36	Perkins	$0, **NR**
4	85-H-07-01-276	NORDAM	$954
4	7-H-2-4-35	NORDAM	$0, **NR**
4	90-173-HO-721	Perkins	$875
4	4-H-10-9-69	Perkins	$0, **NR**
4	4-C-02-12-10	Perkins	$0, **NR**
4	84-H-10-15-1225	NORDAM	$1,151

Table 5.4 Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS continued
(**NR**=not repairable)

Type of W/WS (1-5)	**S/N**	**Repair Vendor**	**Cost of Repair**
4	85-H-07-01-366	NORDAM	$559
4	85-H-09-02-795	Perkins	$0, **NR**
4	5-H-5-23-84	NORDAM	$0, **NR**
5	4-C-5-16-11	Perkins	$0, **NR**
5	4-C-5-28-16	NORDAM	$0, **NR**
5	4-H-8-30-95	NORDAM	$486
5	5-H-2-5-75	Perkins	$0, **NR**
5	2-H-12-15-58	NORDAM	$0, **NR**
5	H-30-67	NORDAM	$0, **NR**
5	7-H-10-14-56	NORDAM	$1,079
5	2-H-6-20-70	Perkins	$0, **NR**
5	2-H-4-24-49	Perkins	$0, **NR**
5	4-C-7-12-22	NORDAM	$881
5	4-H-8-33-64	Perkins	$0, **NR**
5	5-H-12-5-05	NORDAM	$486
5	4-C-6-12-13	Perkins	$0, **NR**
5	2-H-6-29-06	Perkins	$0, **NR**
5	3-H-5-23-79	NORDAM	$881

Table 5.5 C/KC-135 New W/WS Costs

Designation	NSN	Part Number	USAF Cost
#1 Pilot	1560-01-048-1885 FL	5-89354-501	$2,582
#1 Copilot	1560-01-048-1786 FL	5-89354-502	
#2 Pilot	1560-01-009-3320 FL	5-89355-501	$1,445
#2 Copilot	1560-01-008-7396 FL	5-89355-502	
#3 Pilot	1560-00-575-6302 FL	5-89356-501	$1,479
#3 Copilot	1560-00-575-6297 FL	5-89356-502	
#4 Pilot	1560-00-575-6299 FL	5-71764-501	$1,372
#4 Copilot	1560-00-575-6298 FL	5-71764-502	
#5 Pilot	1560-00-575-6300 FL	5-89358-501	$1,078
#5 Copilot	1560-00-575-6301 FL	5-89358-502	

Table 5.6 Repair Cost Comparison Data for C/KC-135 W/WS

Type of W/WS	Cost as a Percentage of New Purchase Price		
	High*	Actual	Low*
1	81	75	61
2	132	-	83
3	87	-	41
4	71	65	41
5	100	-	45

* Based on Extremes of Estimates, Actual Costs, and Quotes from NORDAM and Perkins Aircraft Services, assuming a 20-percent volume discount from Perkins

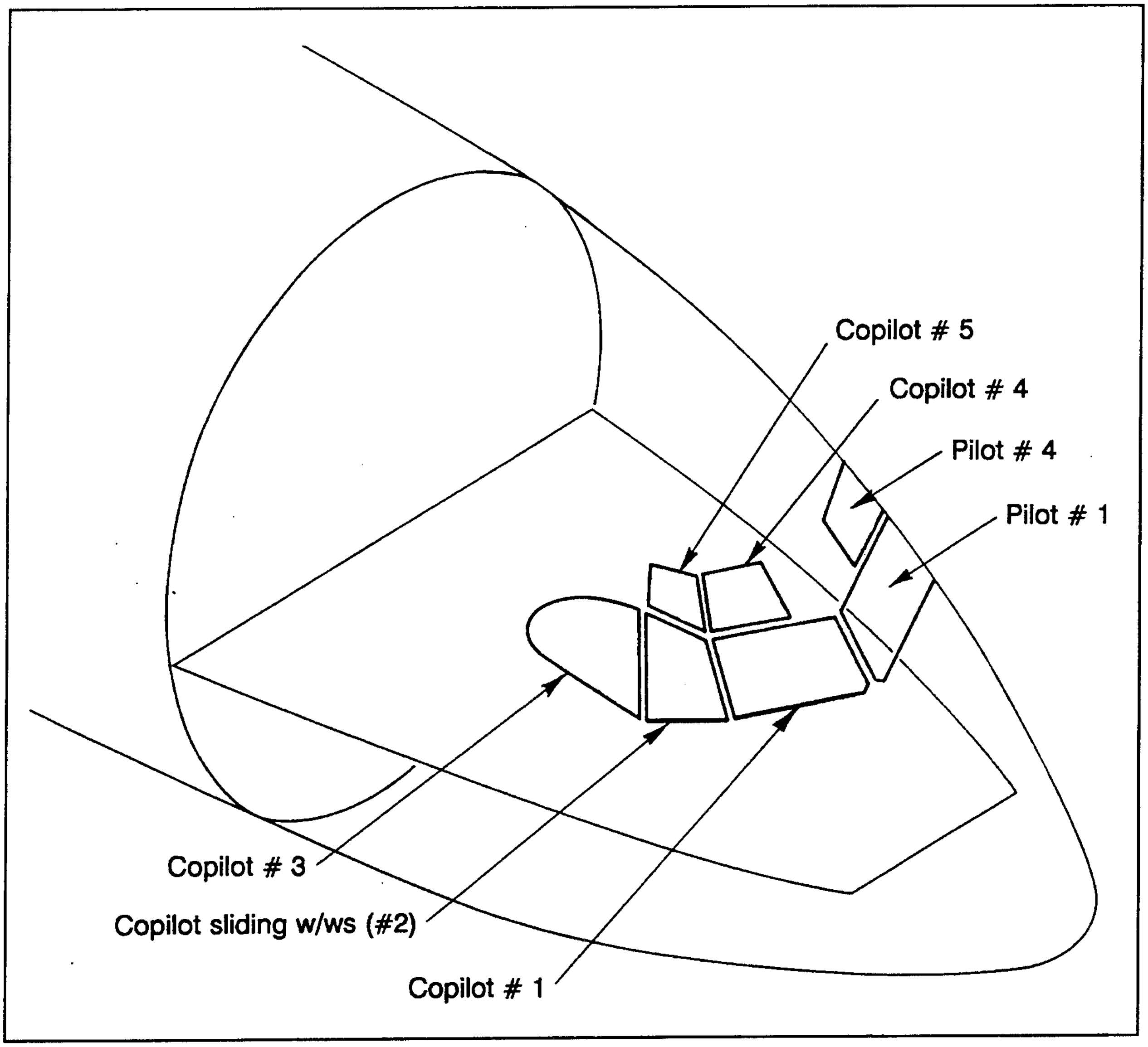


Figure 2.1 C/KC-135 W/WS Identification

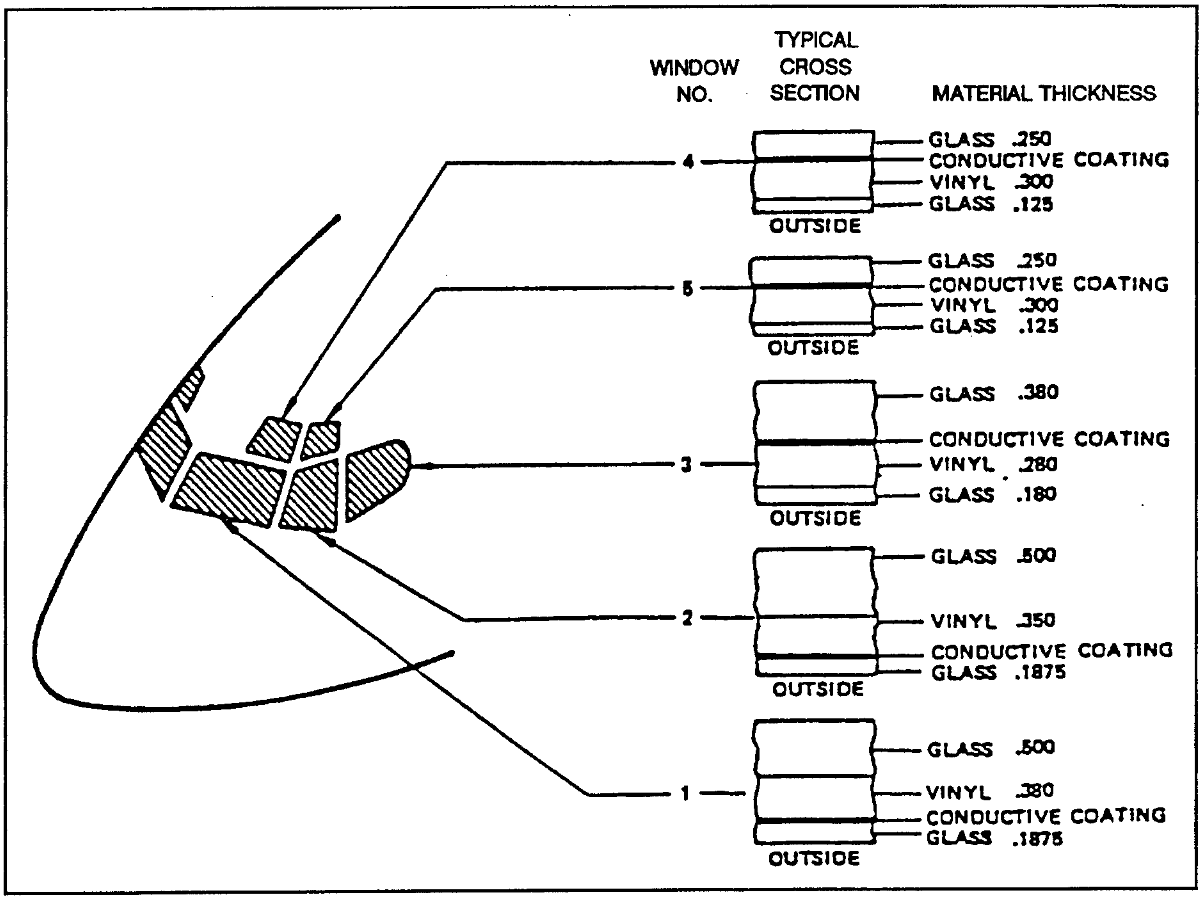


Figure 2.2 C/KC-135 W/WS Construction

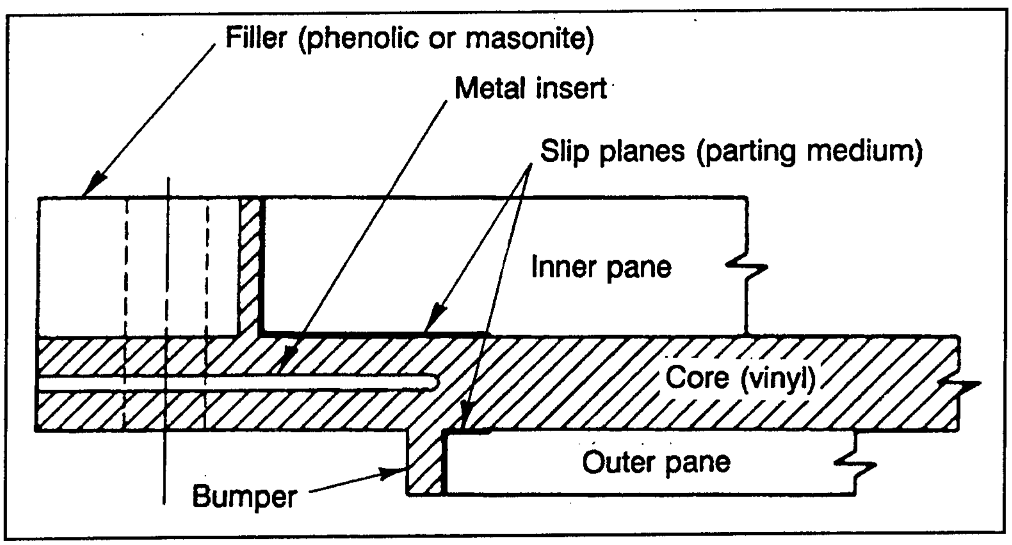


Figure 2.3 W/WS Construction Showing Location of Slip Planes

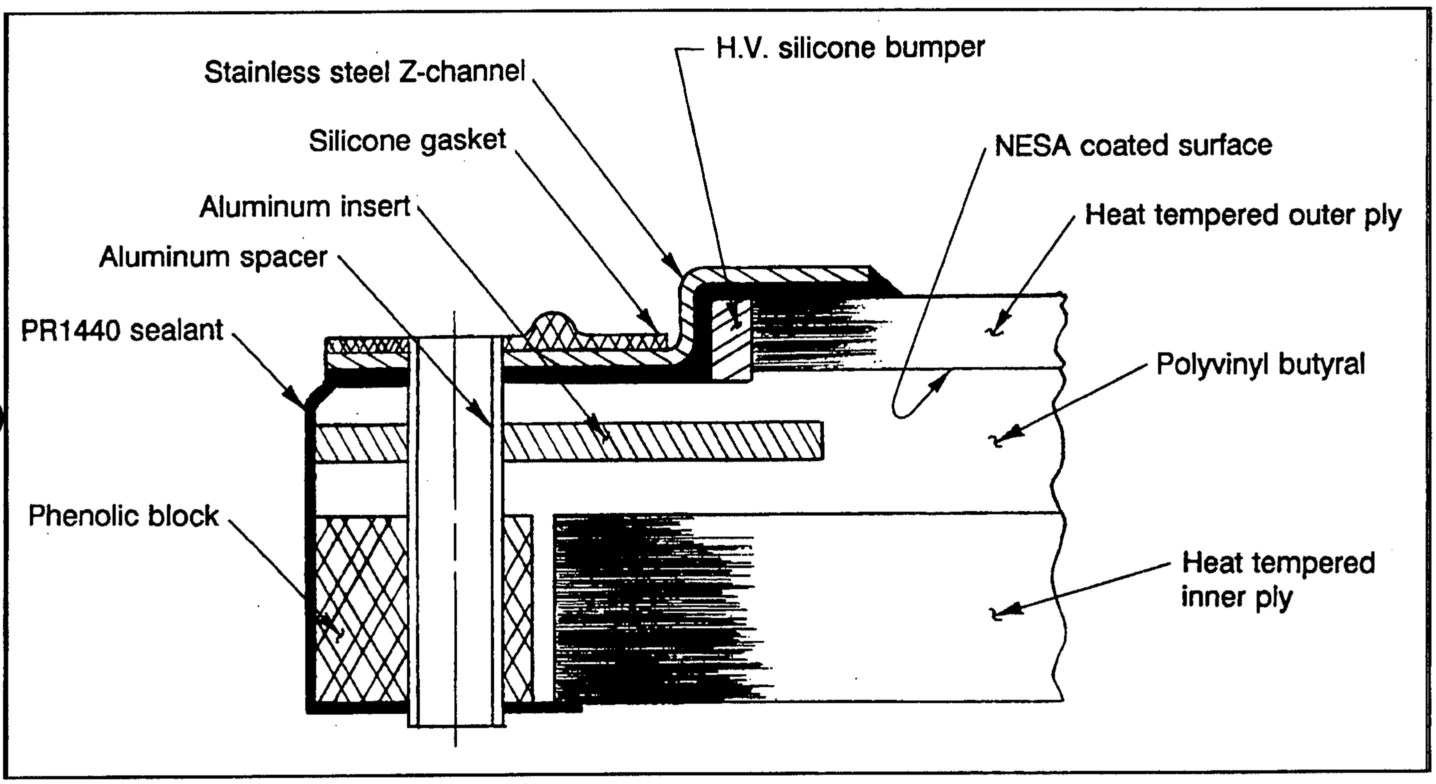


Figure 2.4 C/KC-135 #1 W/WS Cross-Section

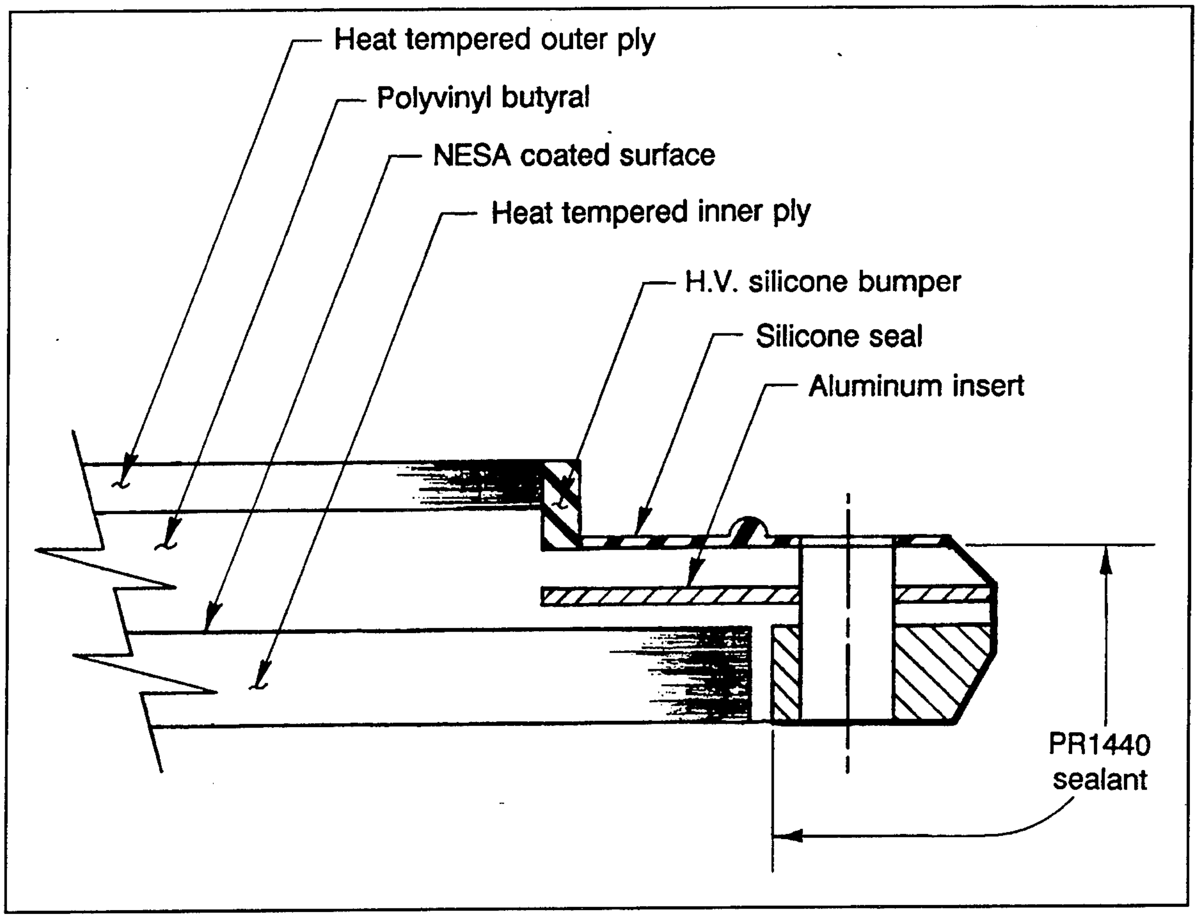


Figure 2.5 C/KC-135 #4 W/WS Cross-Section

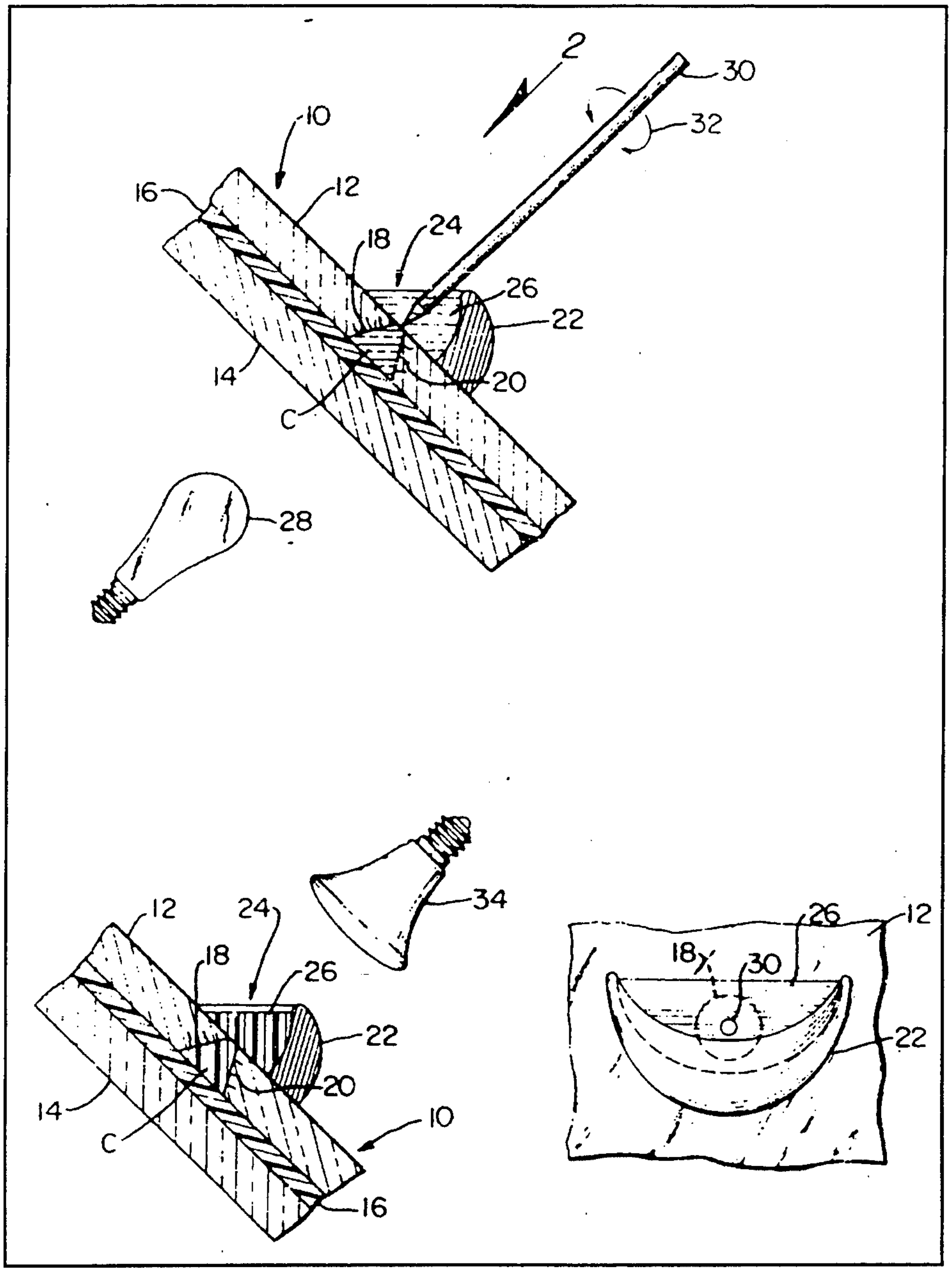


Figure 3.1 The Glass Doctor Patented Technique for Repair of Conical Cracks in Laminated Glass, U.S. Patent # 3,841,932

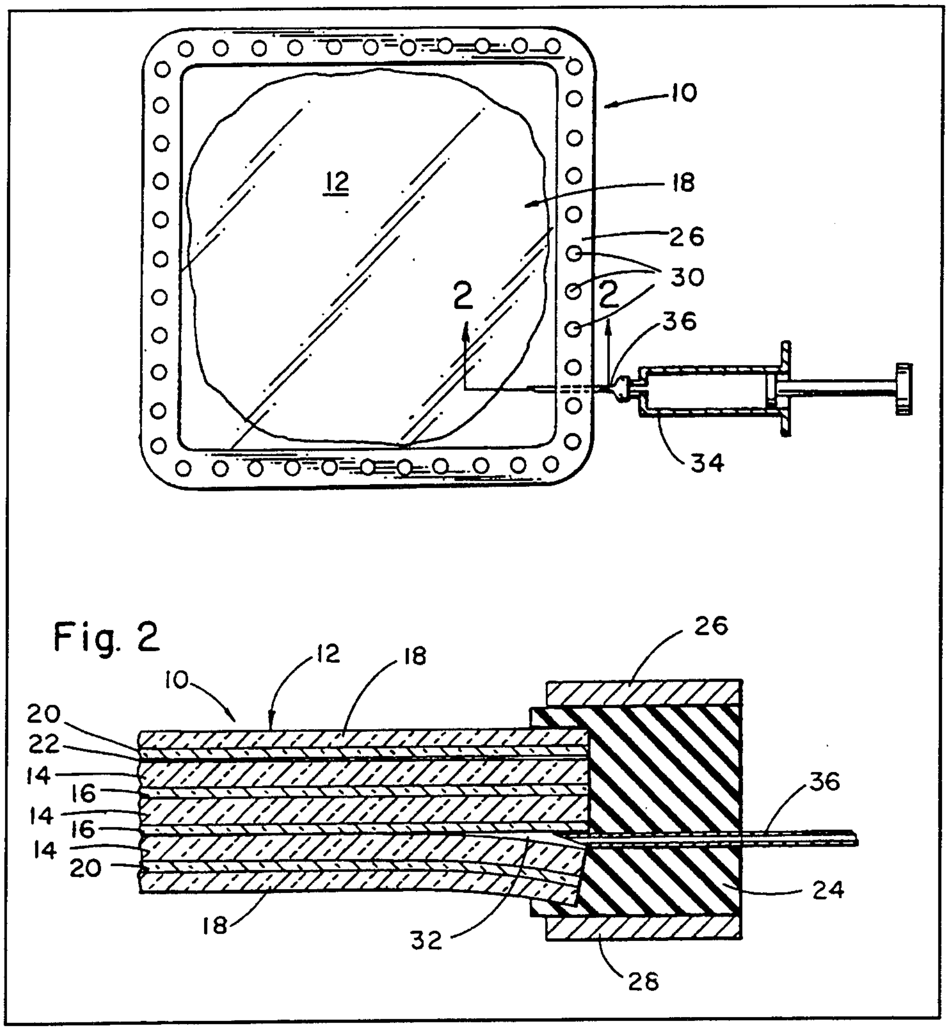
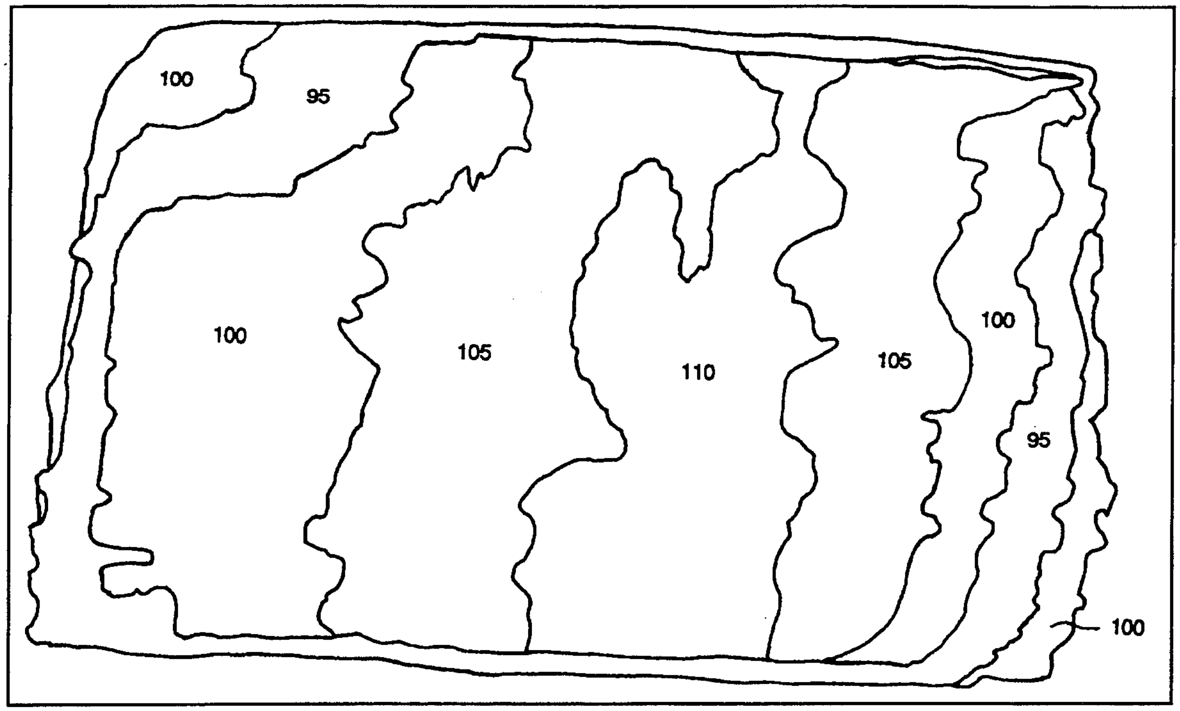
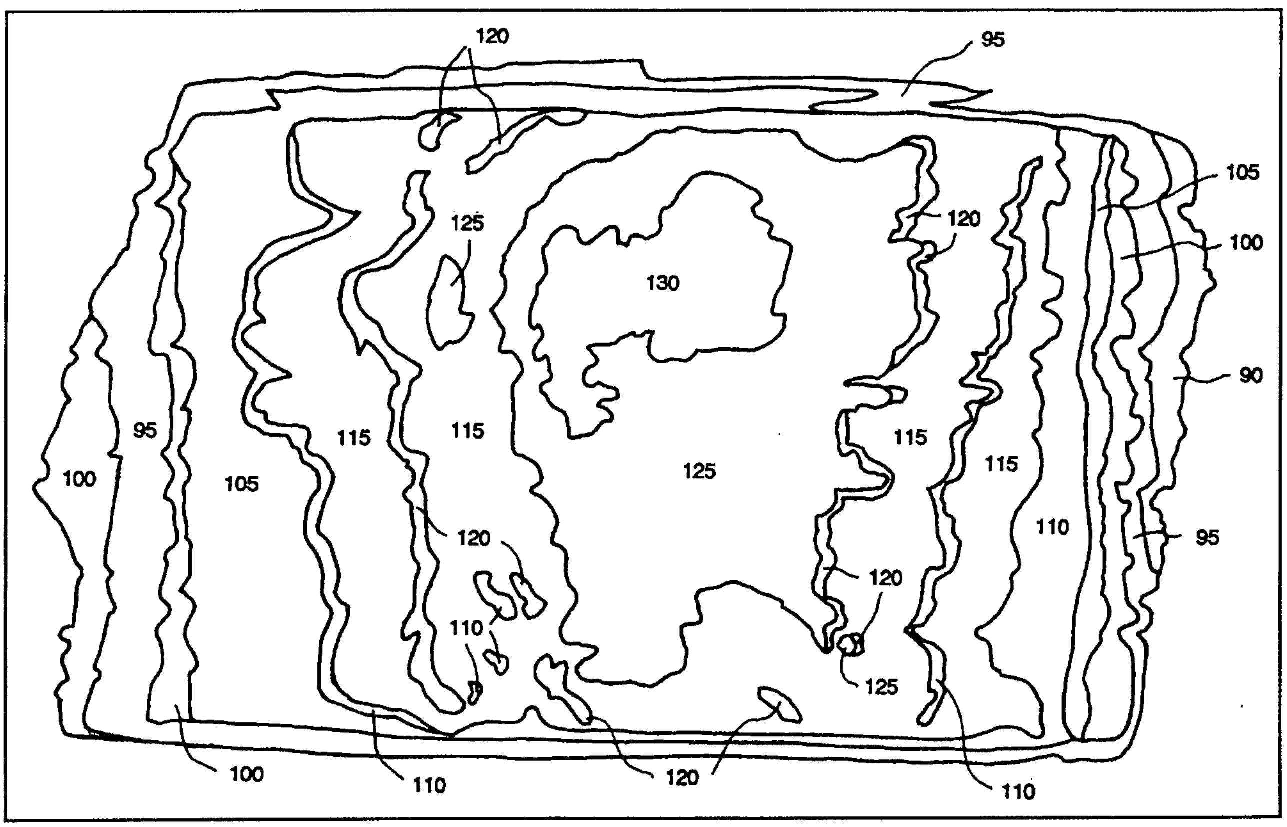


Figure 3.2 The Glass Doctor Patented Technique for Repair of Delaminations, U.S. Patent # 4,780,162

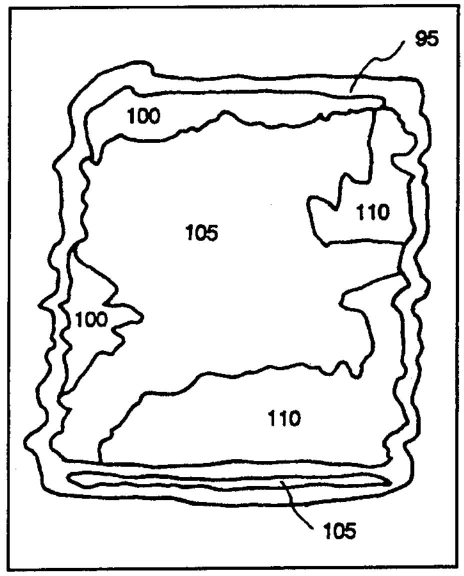


a) Typical (S/N 86-H-10-06-062)

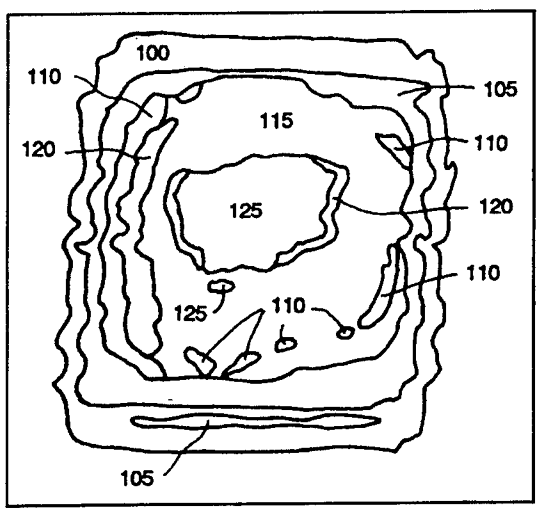


b) Most Out-of-the-Ordinary (S/N 82-H-9-6-537)

Figure 4.1 C/KC-135 #1 Thermal Images From the Heater Test



a) Typical (S/N 92-064-HO-471)



b) Most Out-of-the-Ordinary (S/N 92-093-HO-392)

Figure 4.2 C/KC-135 #4 W/WS Thermal Images From the Heater Test

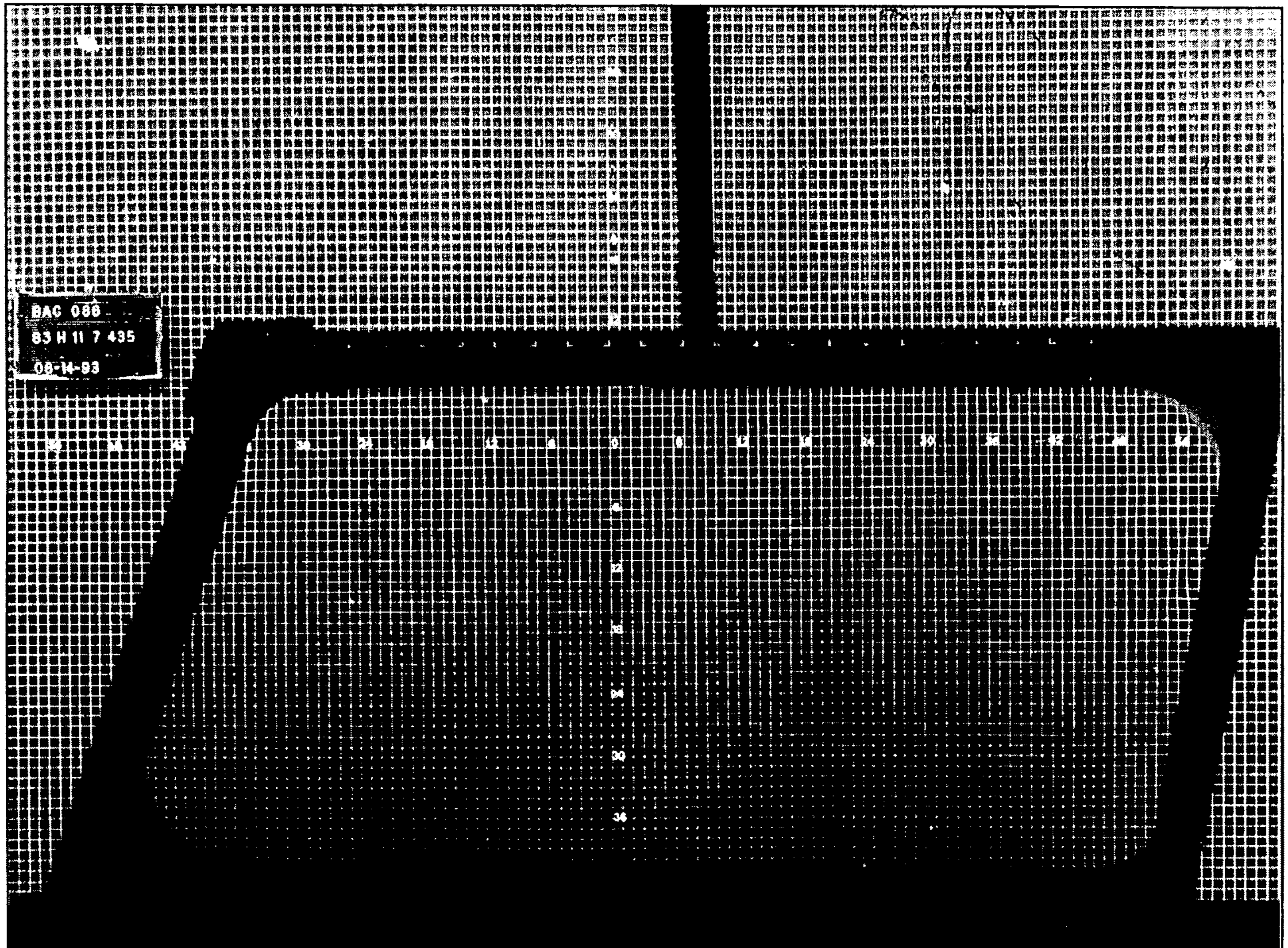


Figure 4.3 Worst Optical Distortion Found in Any C/KC-135 #1 W/WS (S/N 83-H-11-7-432)

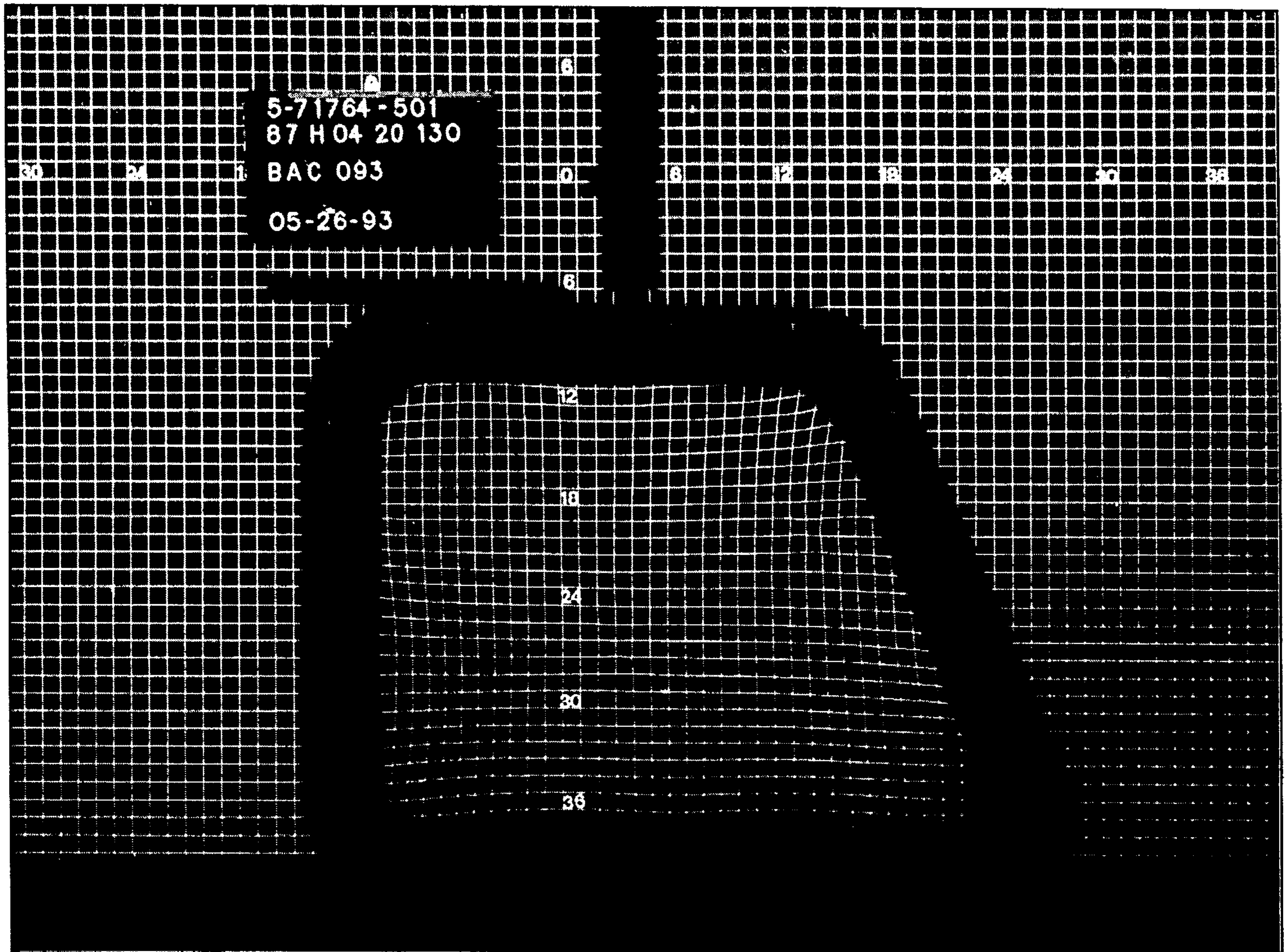


Figure 4.4 Worst Optical Distortion Found in Any C/KC-135 #4 W/WS (S/N 87-H-04-20-130)

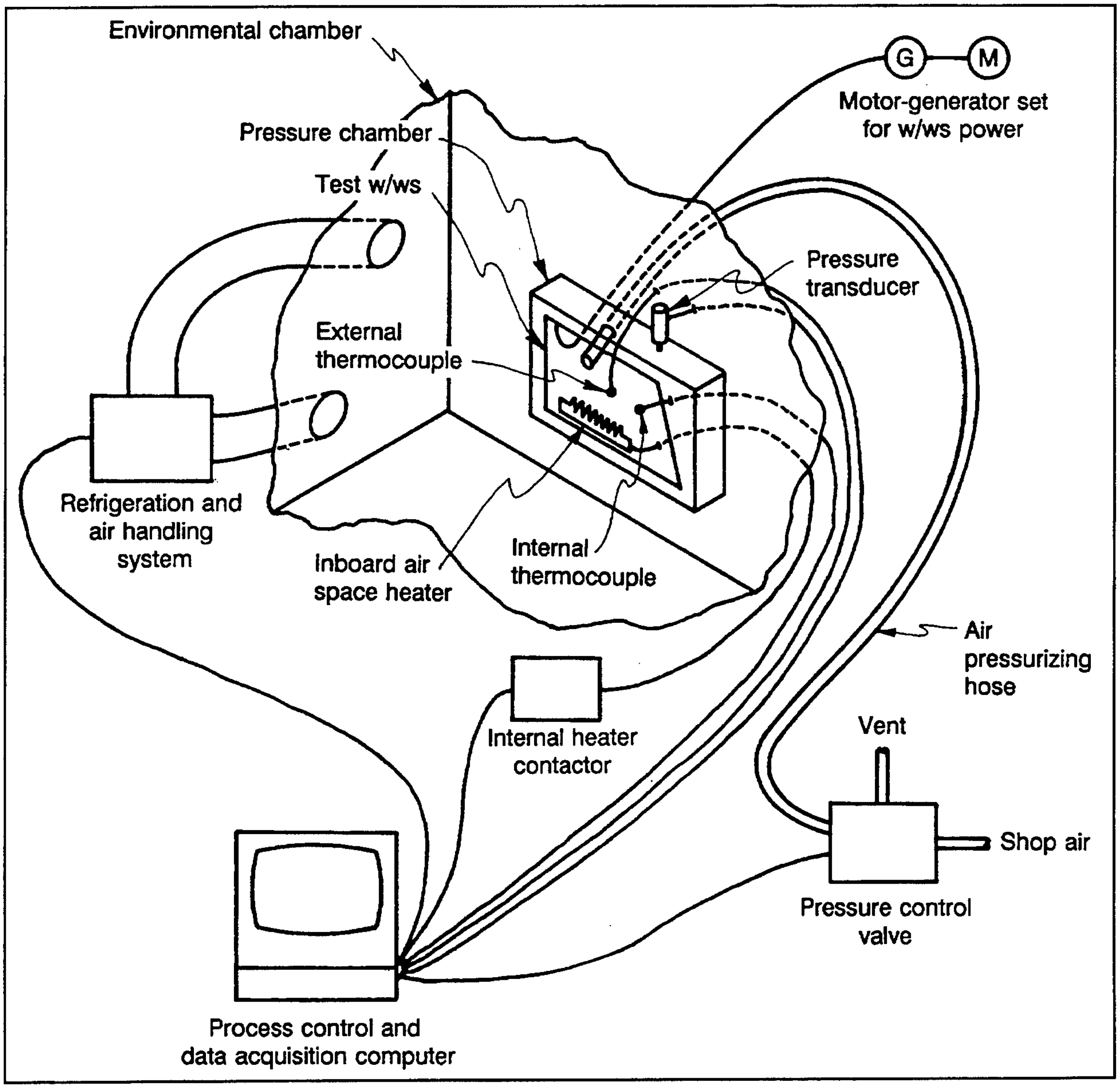


Figure 4.5 Pressure Integrity Testing Facility

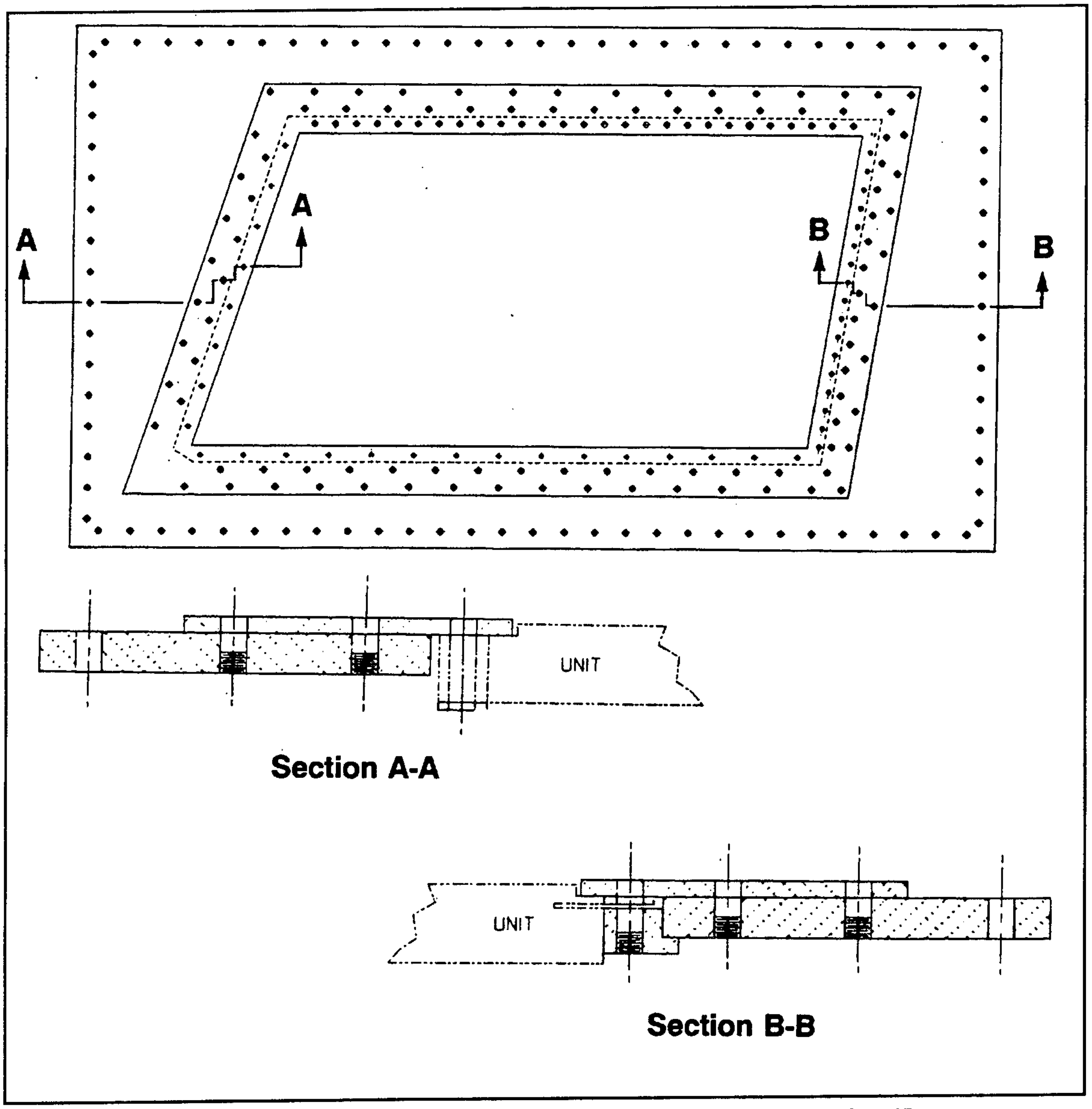


Figure 4.6 C/KC-135 #1 W/WS Pressure Integrity Mounting Frame

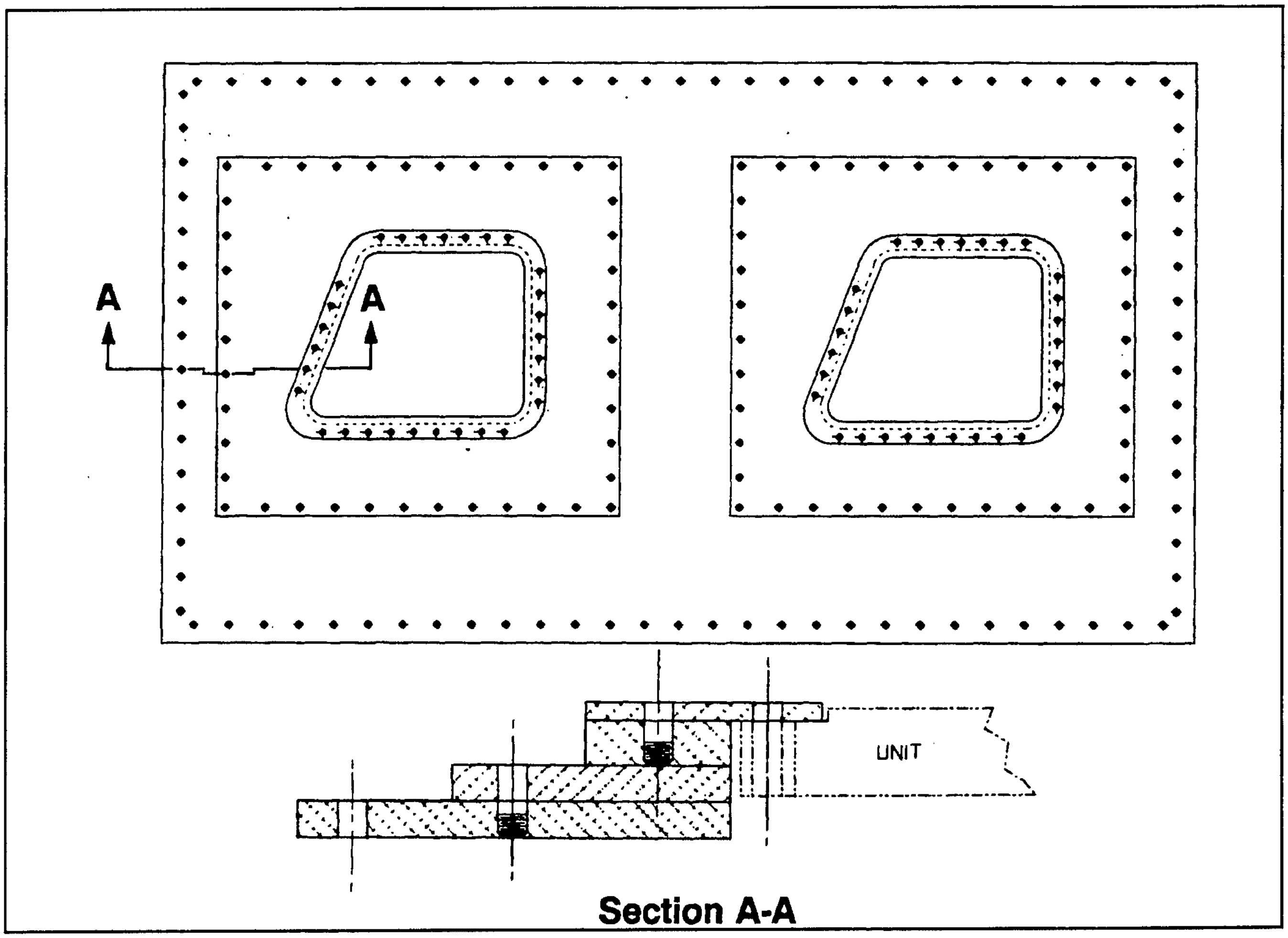
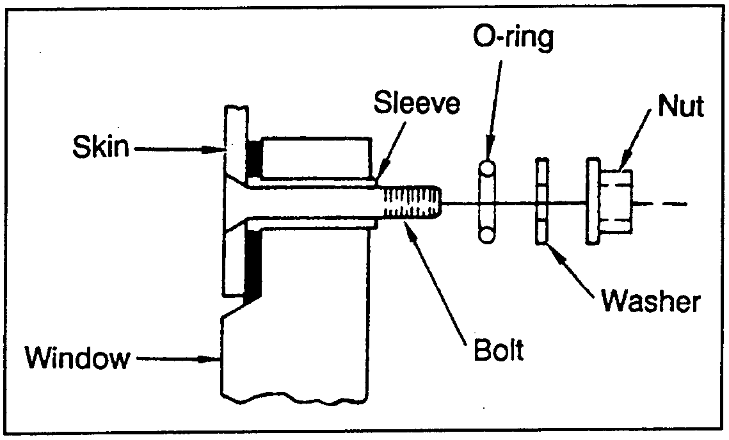
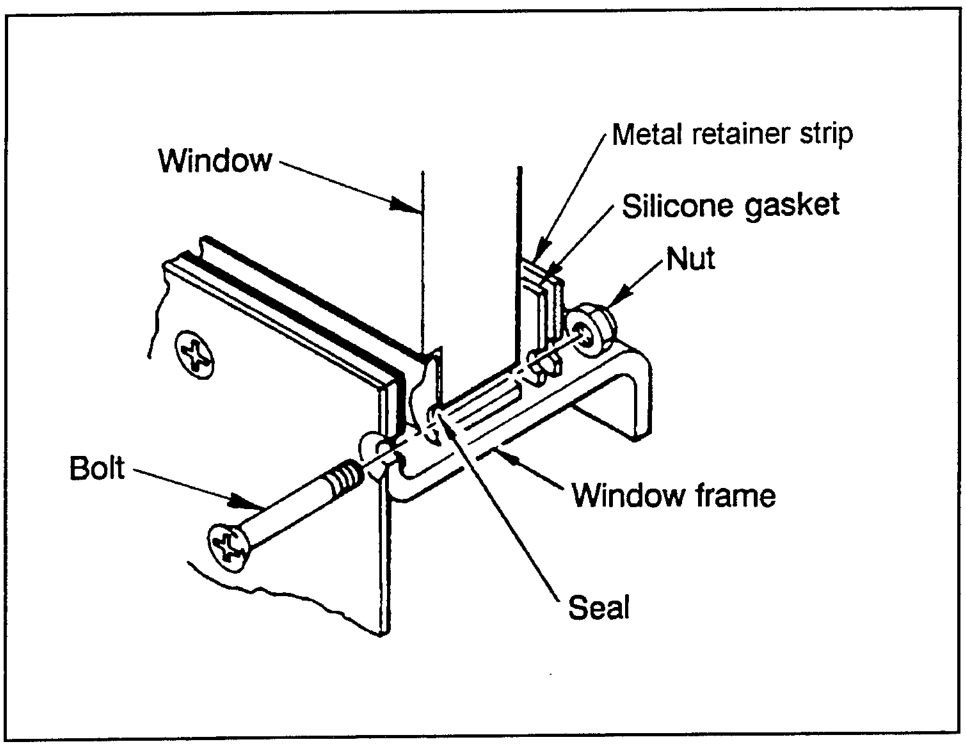


Figure 4.7 C/KC-135 #4 W/WS Pressure Integrity Mounting Frame



a) #1 W/WS



b) #4 W/WS

Figure 4.8 C/KC-135 W/WS Mounting Details

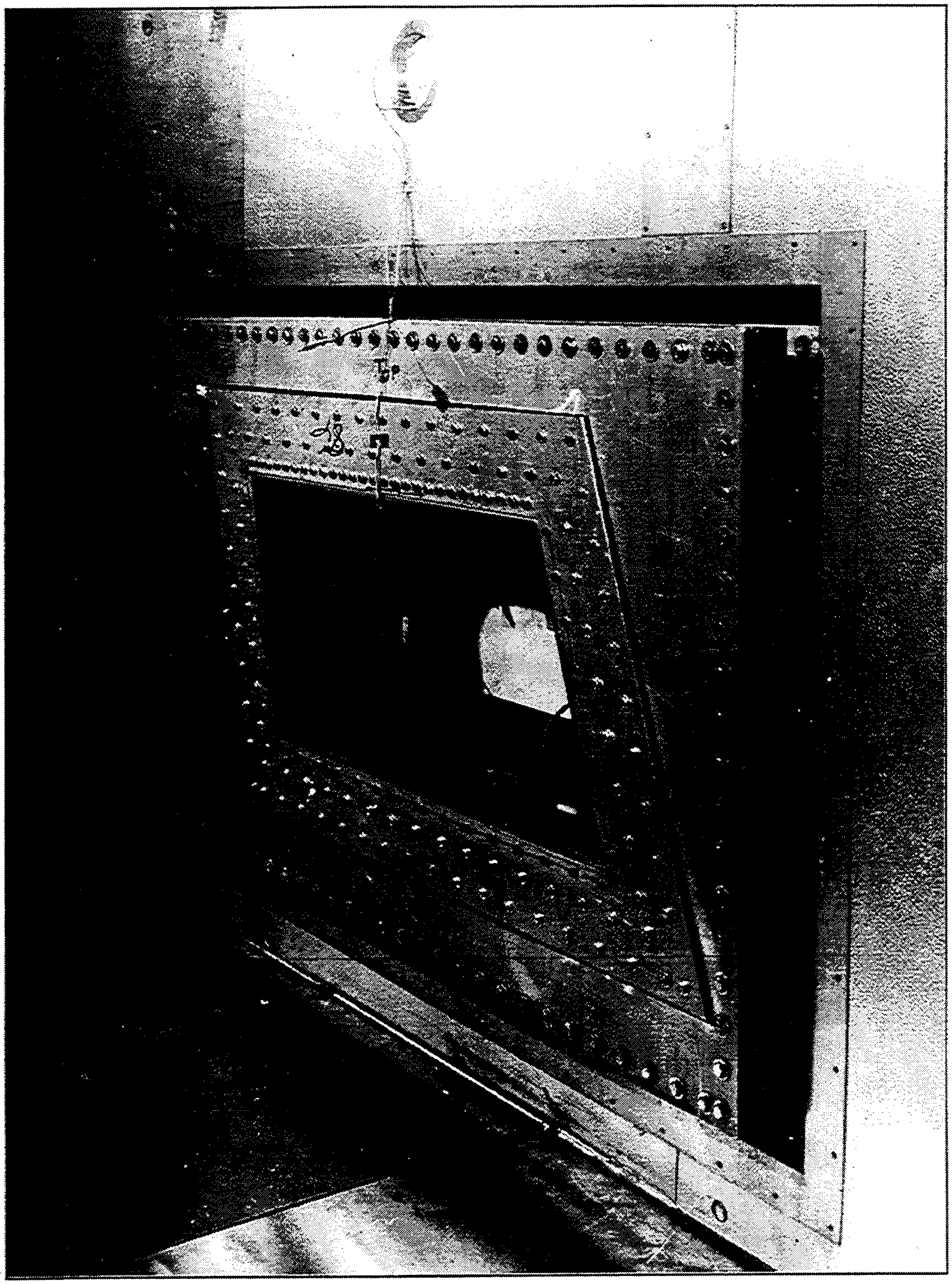


Figure 4.9 Typical C/KC-135 #1 W/WS Pressure Integrity Test Set Up

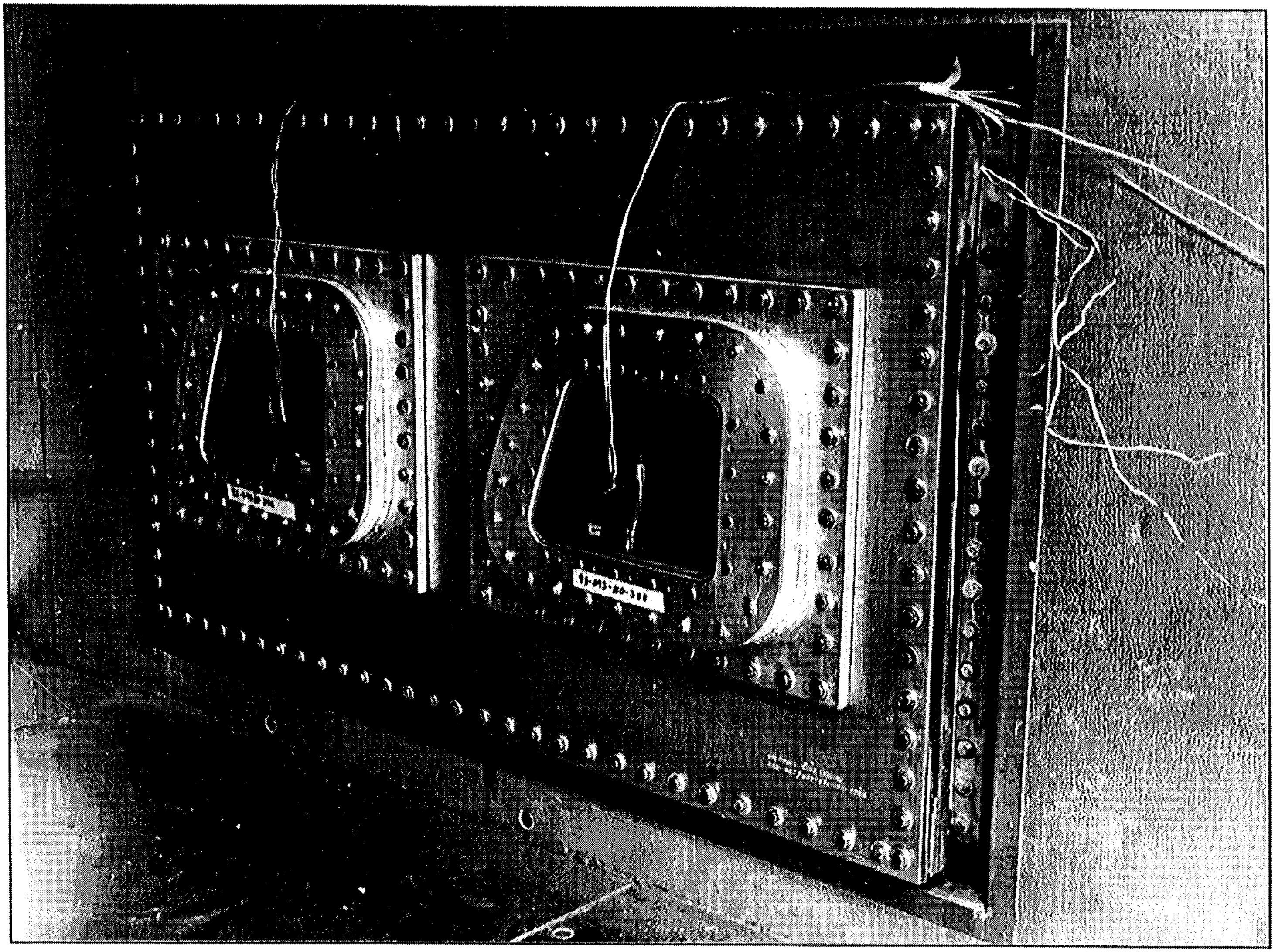


Figure 4.10 Typical C/KC-135 #4 W/WS Pressure Integrity Test Set Up

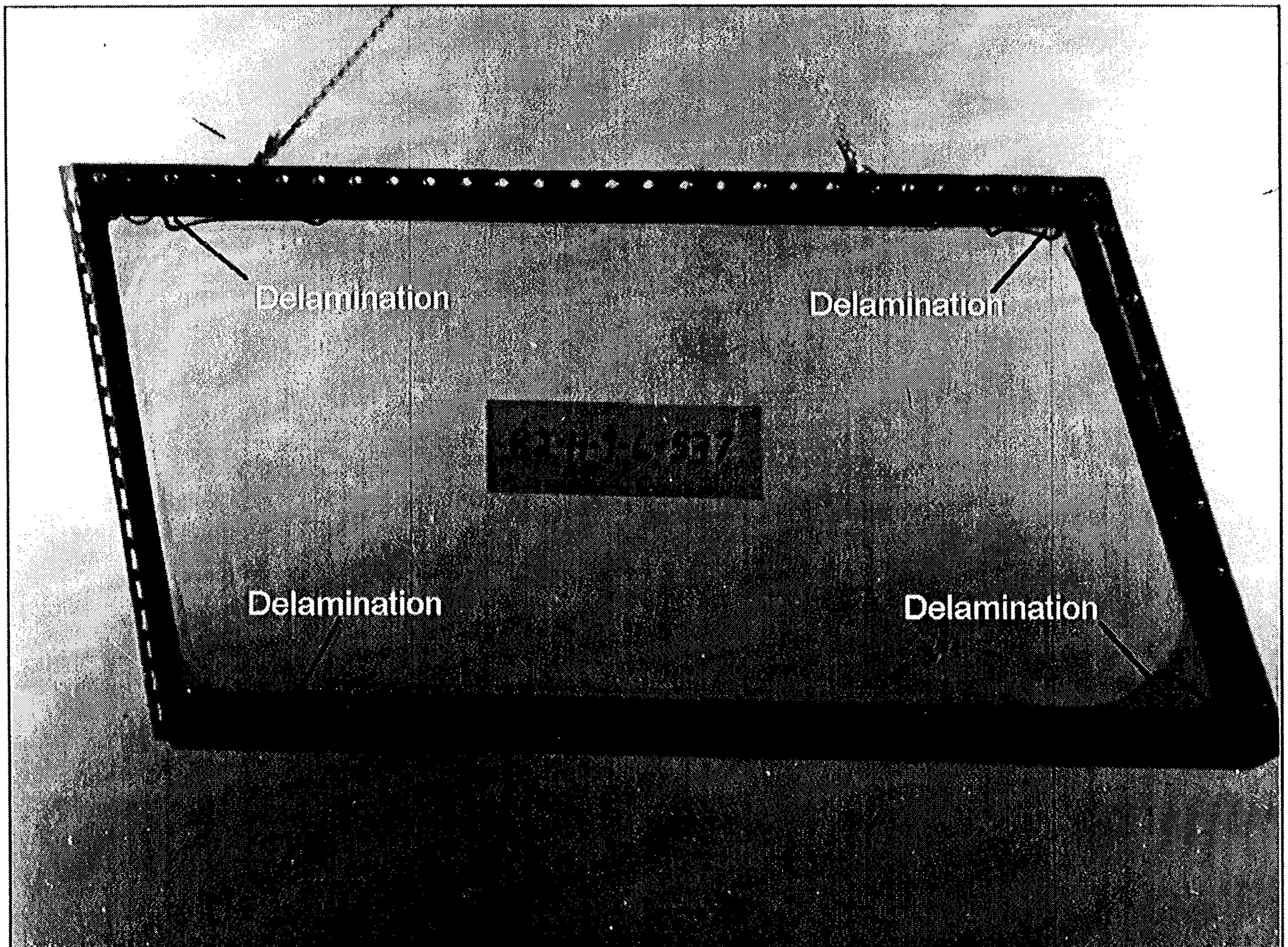


Figure 4.11 Worst Delamination Observed in a C/KC-135 #1 W/WS From Pressure Cycling (Repaired W/WS, S/N 82-H-09-06-537)

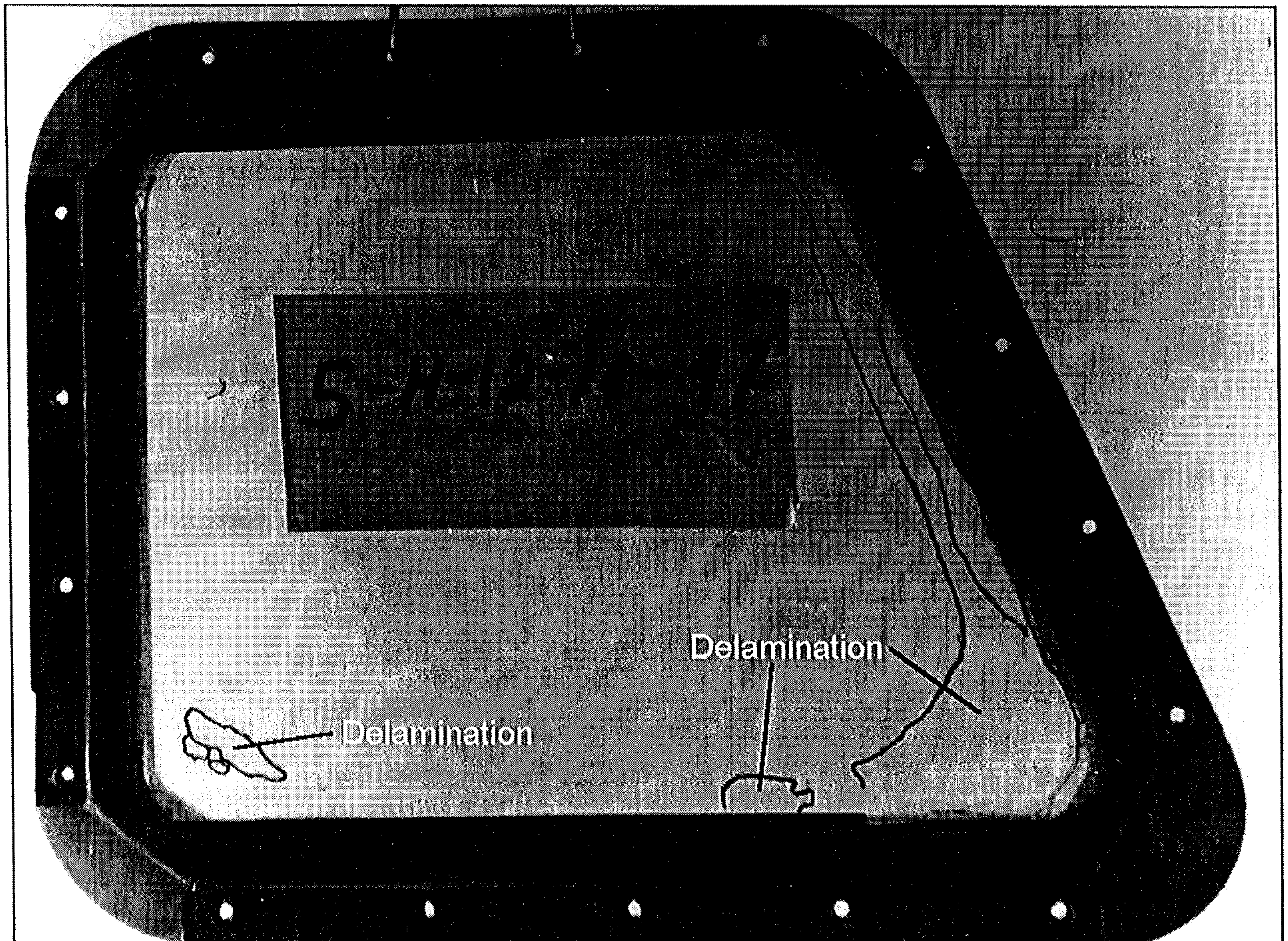


Figure 4.12 Worst Delamination Observed in a C/KC-135 #4 W/WS From Pressure Cycling (Repaired W/WS, S/N 5-H-12-16-47)

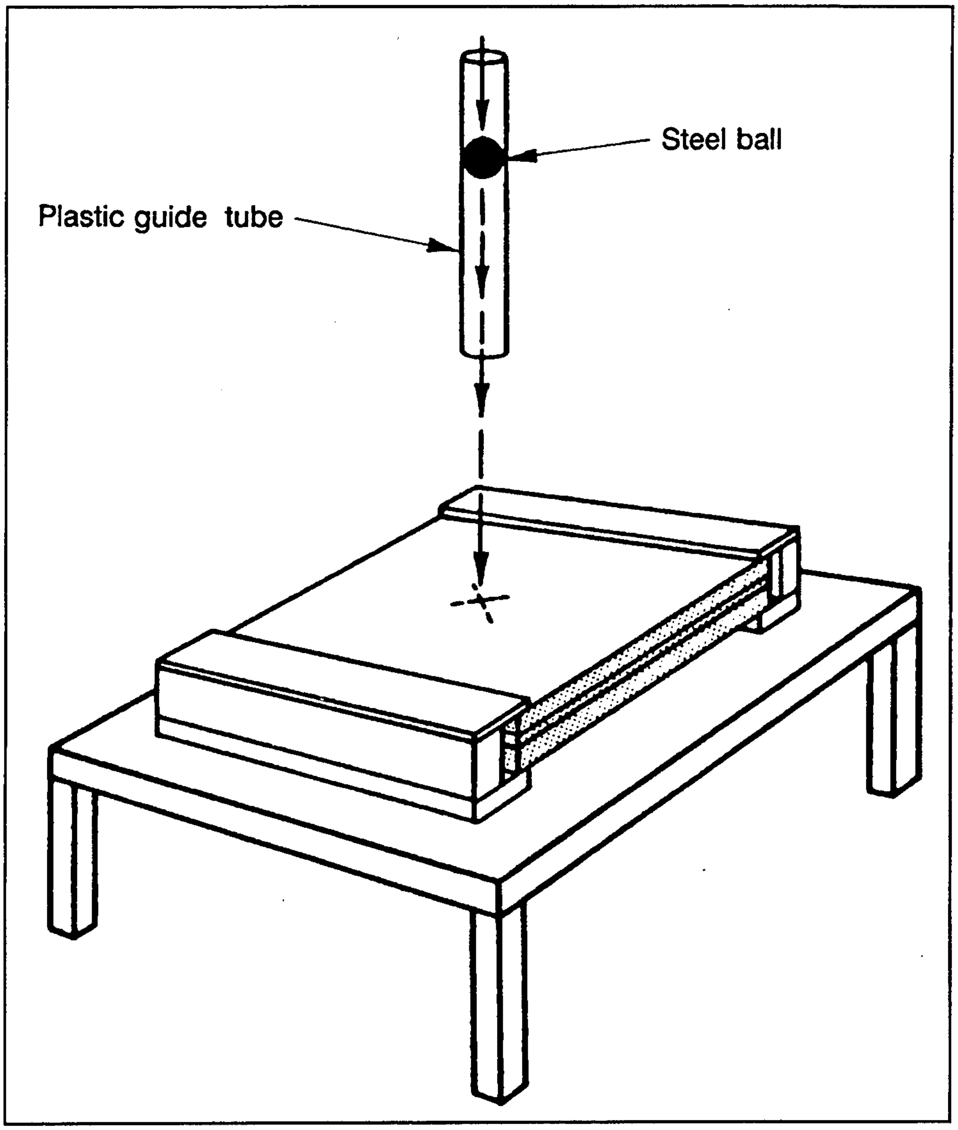


Figure 4.13 Residual Strength Falling Ball Test

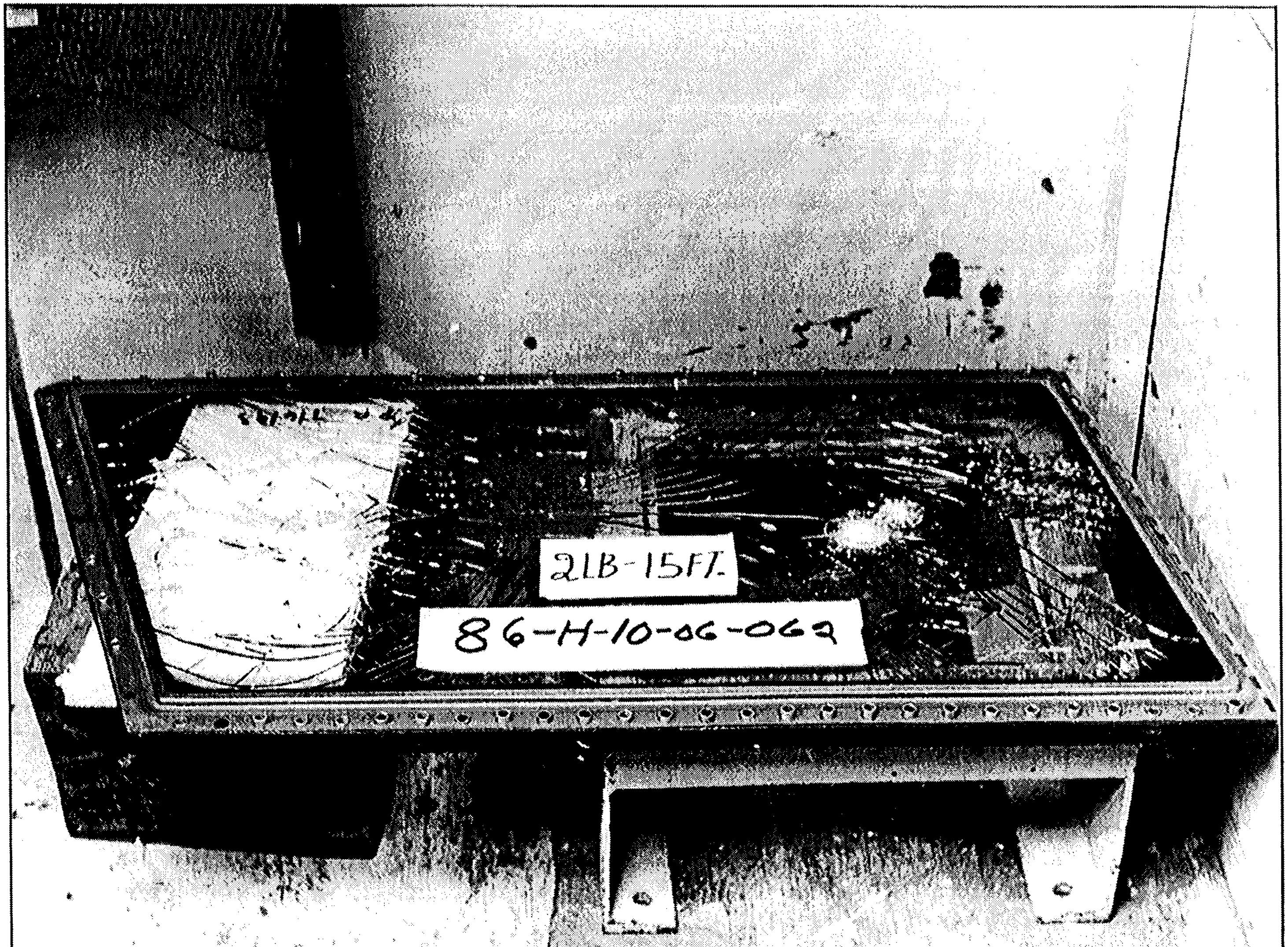


Figure 4.14 #1 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Consequences of Two Ball Drops (New W/WS, S/N 86-H-10-06-062)

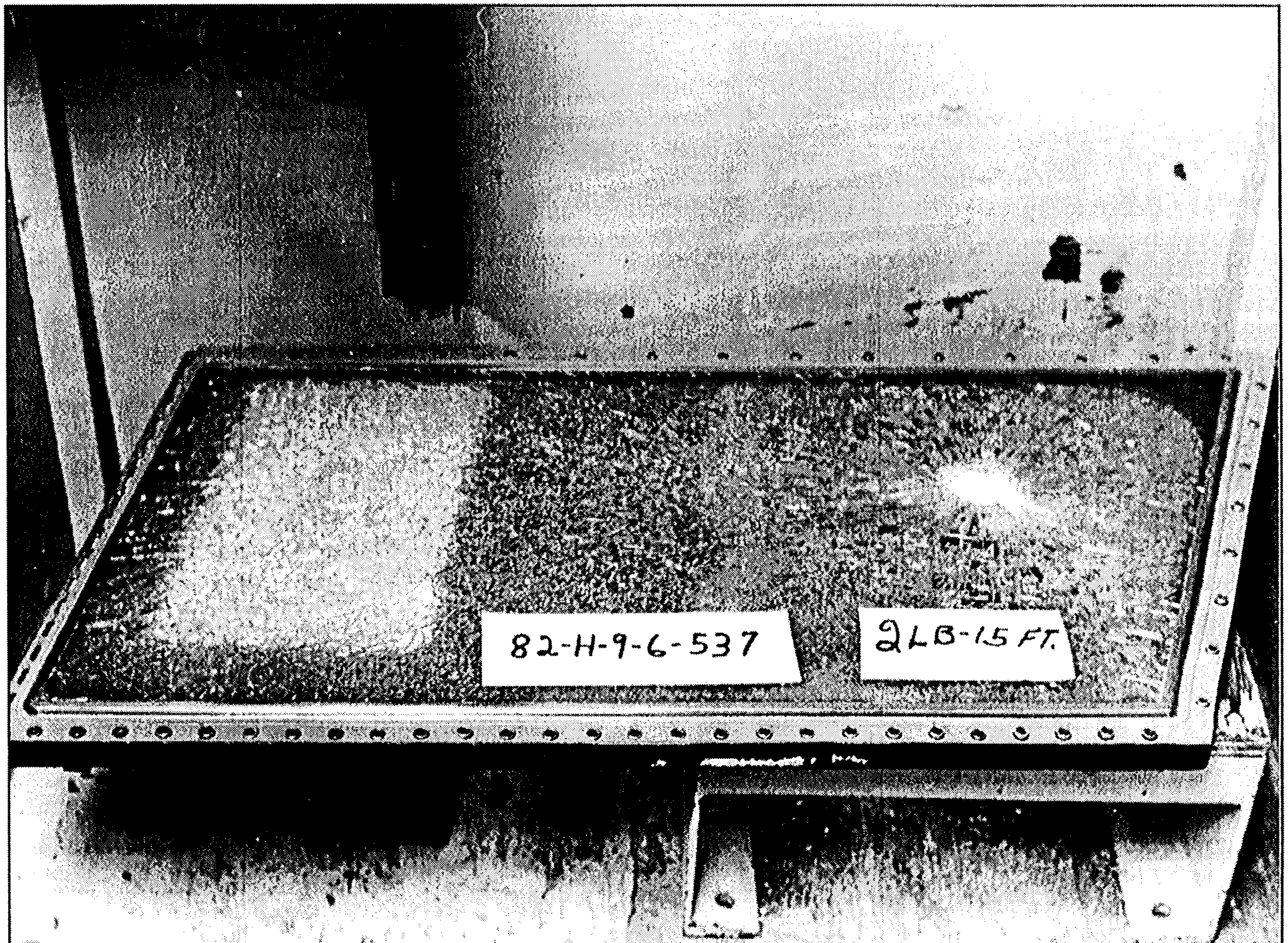


Figure 4.15 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Outboard View (S/N 82-H-9-6-537)

Figure 4.16 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Inboard View (S/N 82-H-9-6-537)

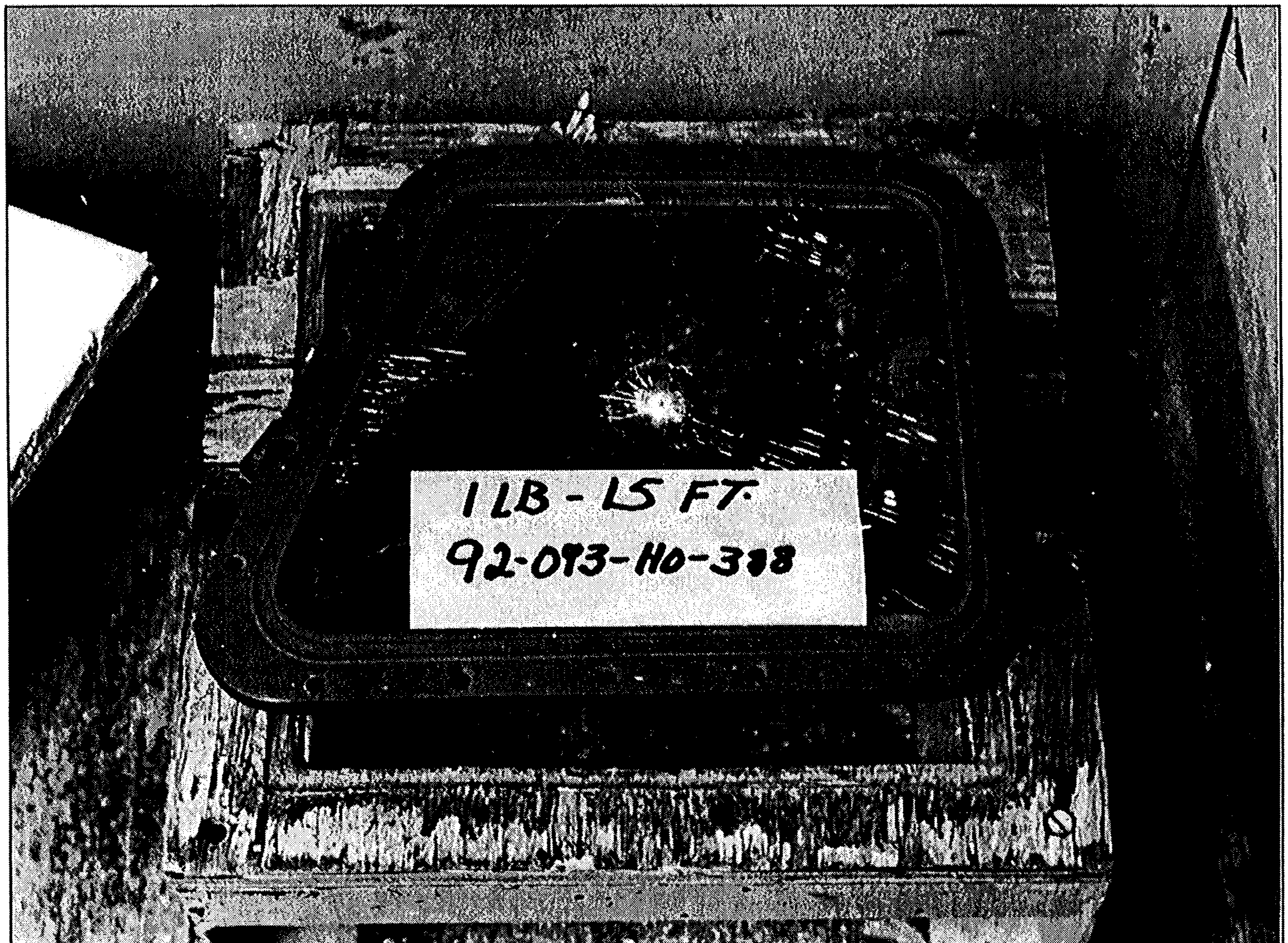


Figure 4.17 #4 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Test Result
(New W/WS, S/N 92-093-HO-388)

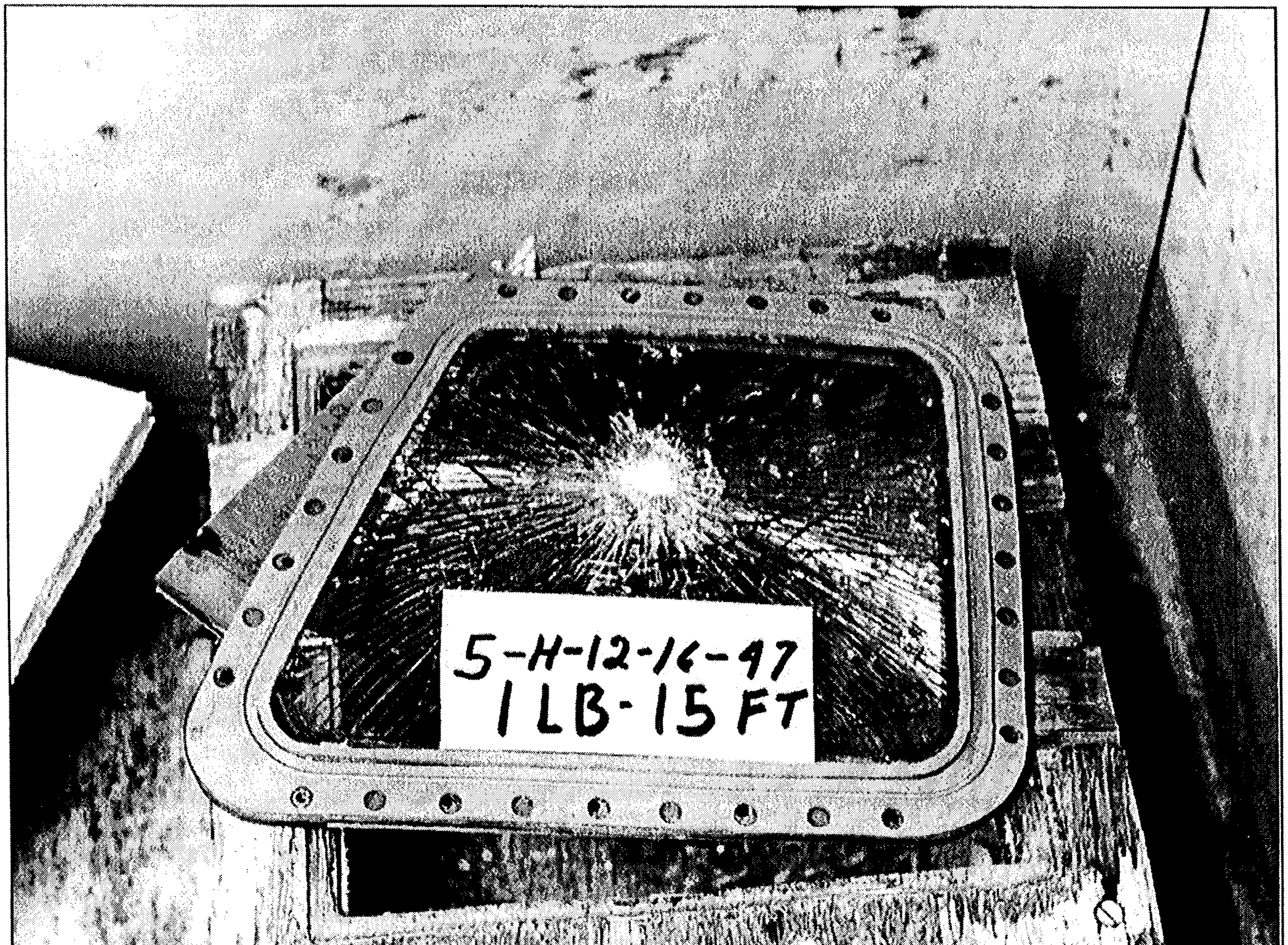


Figure 4.18 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Outboard View (S/N 5-H-12-16-47)

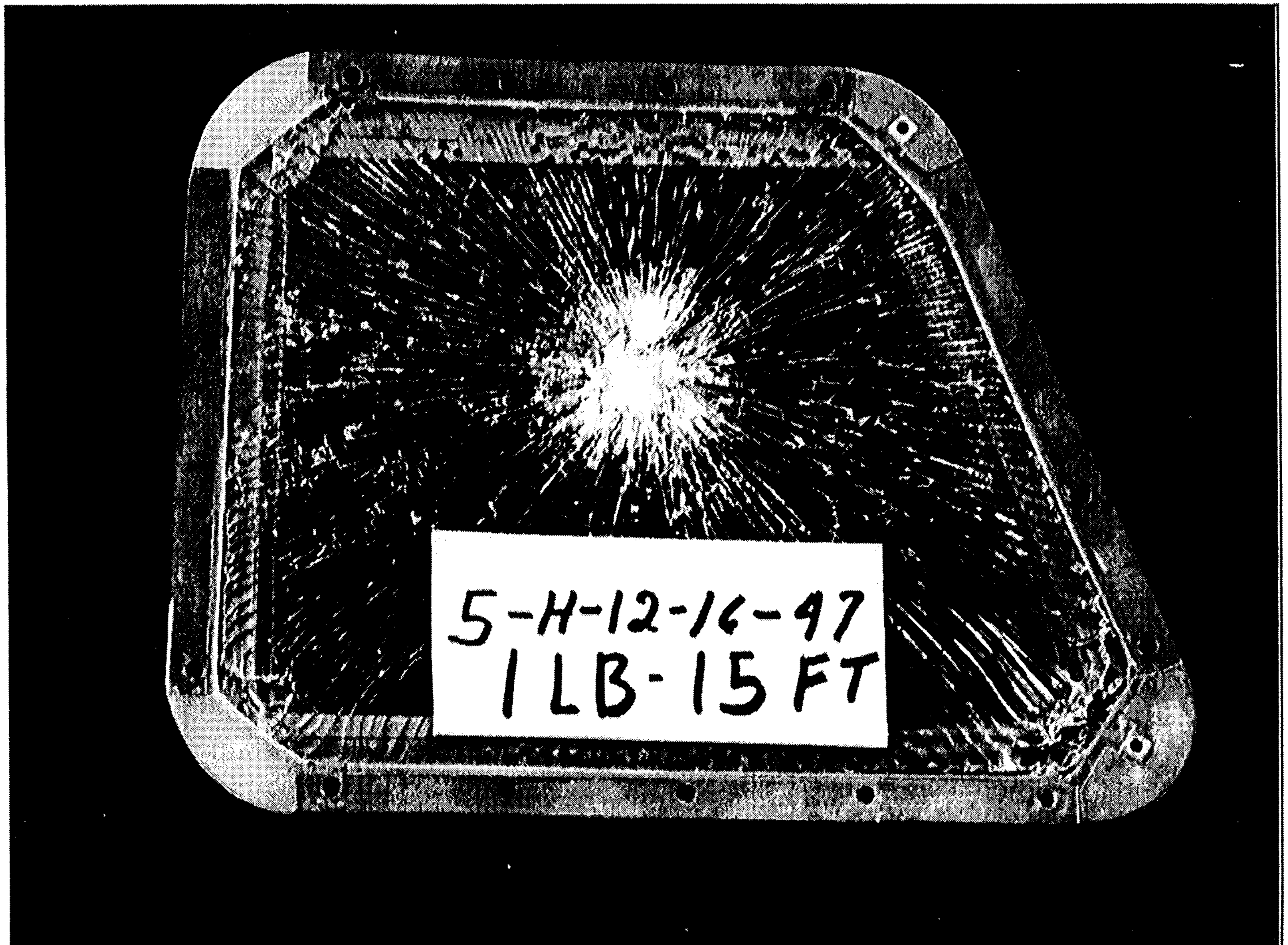


Figure 4.19 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Inboard View (S/N 5-H-12-16-47)

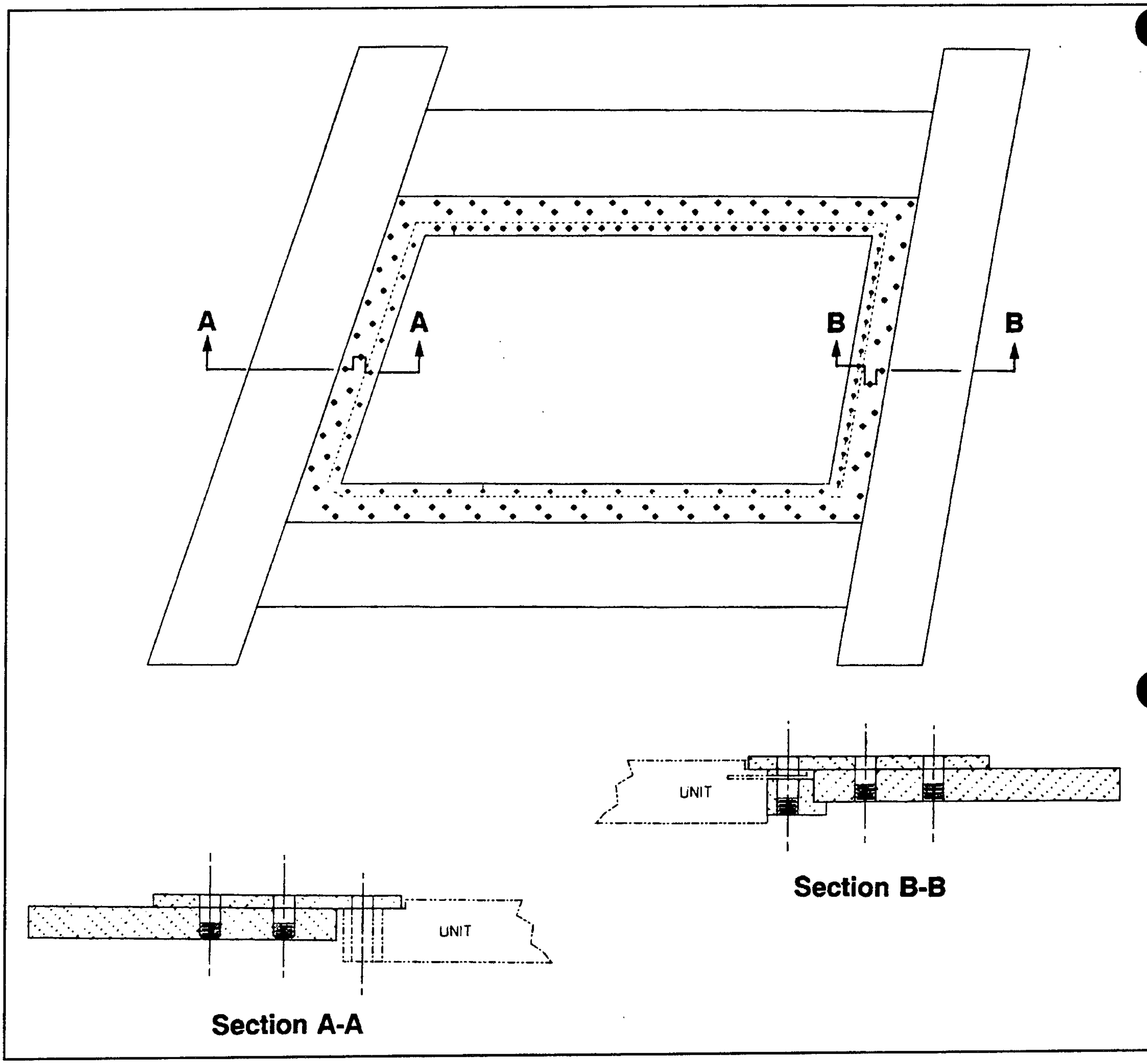


Figure 4.20 C/KC-135 #1 W/WS Bird Impact Mounting Frame

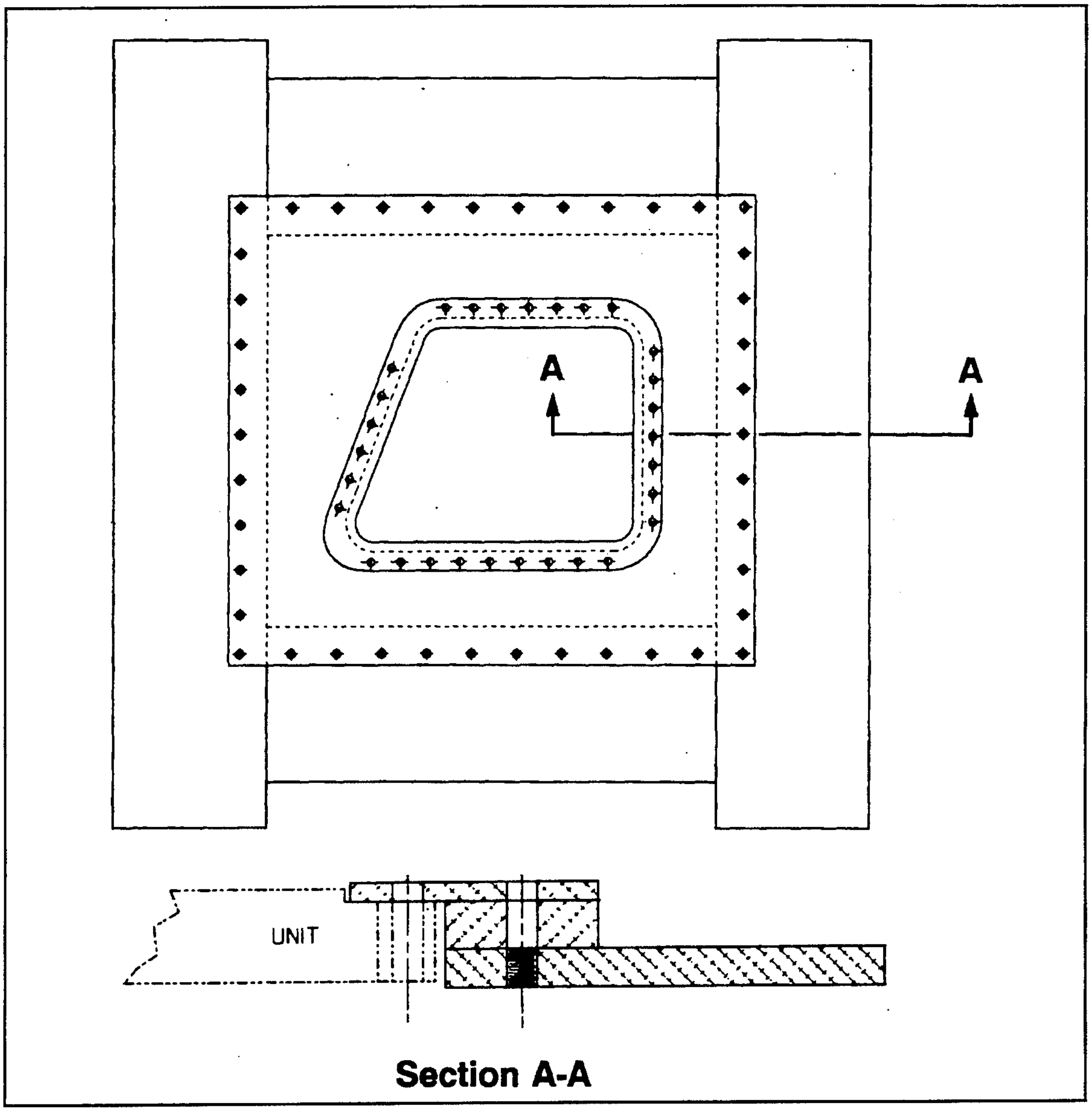


Figure 4.21 C/KC-135 #4 W/WS Bird Impact Mounting Frame

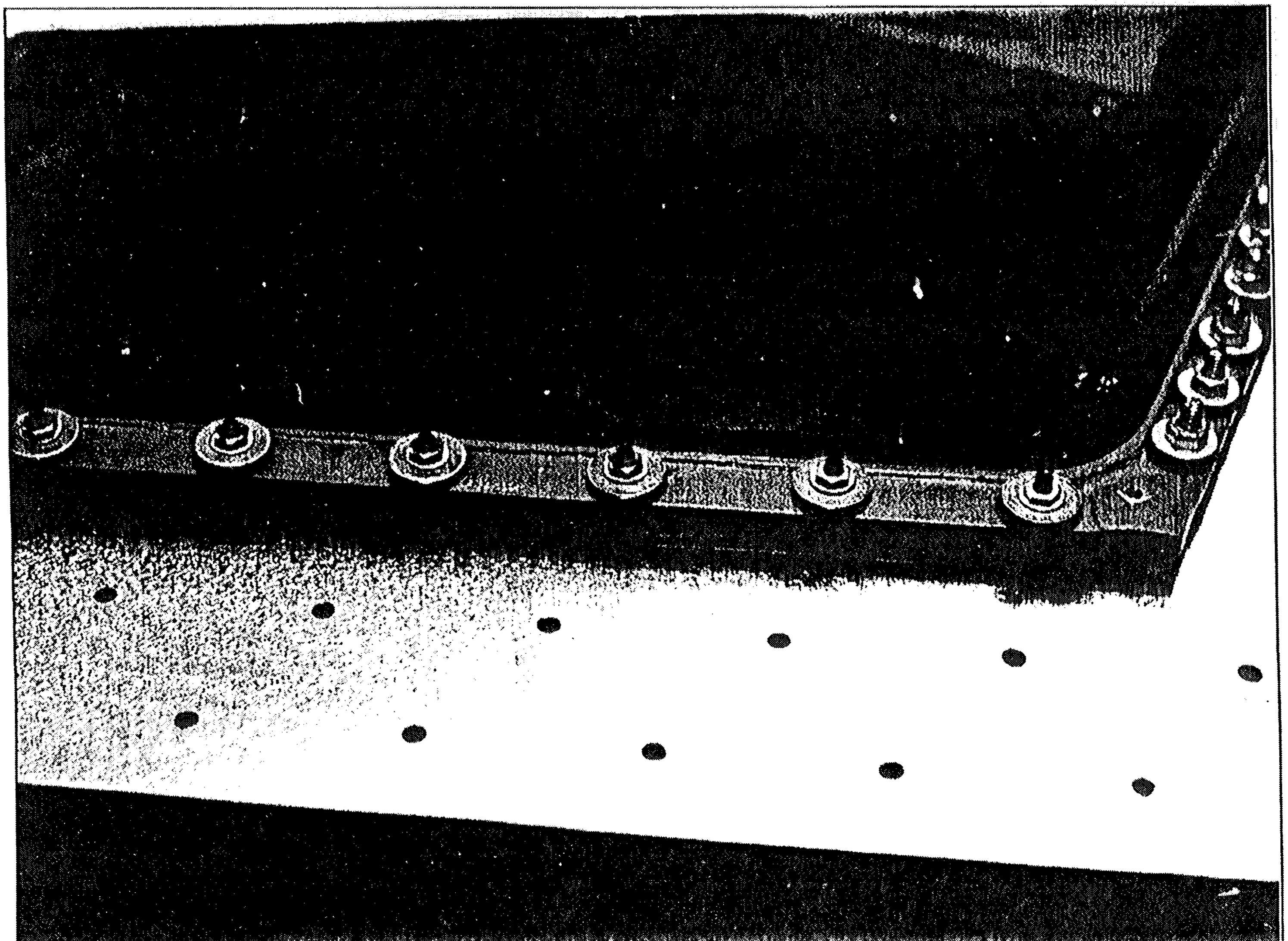


Figure 4.22 C/KC-135 #1 W/WS Mounting Hardware Details

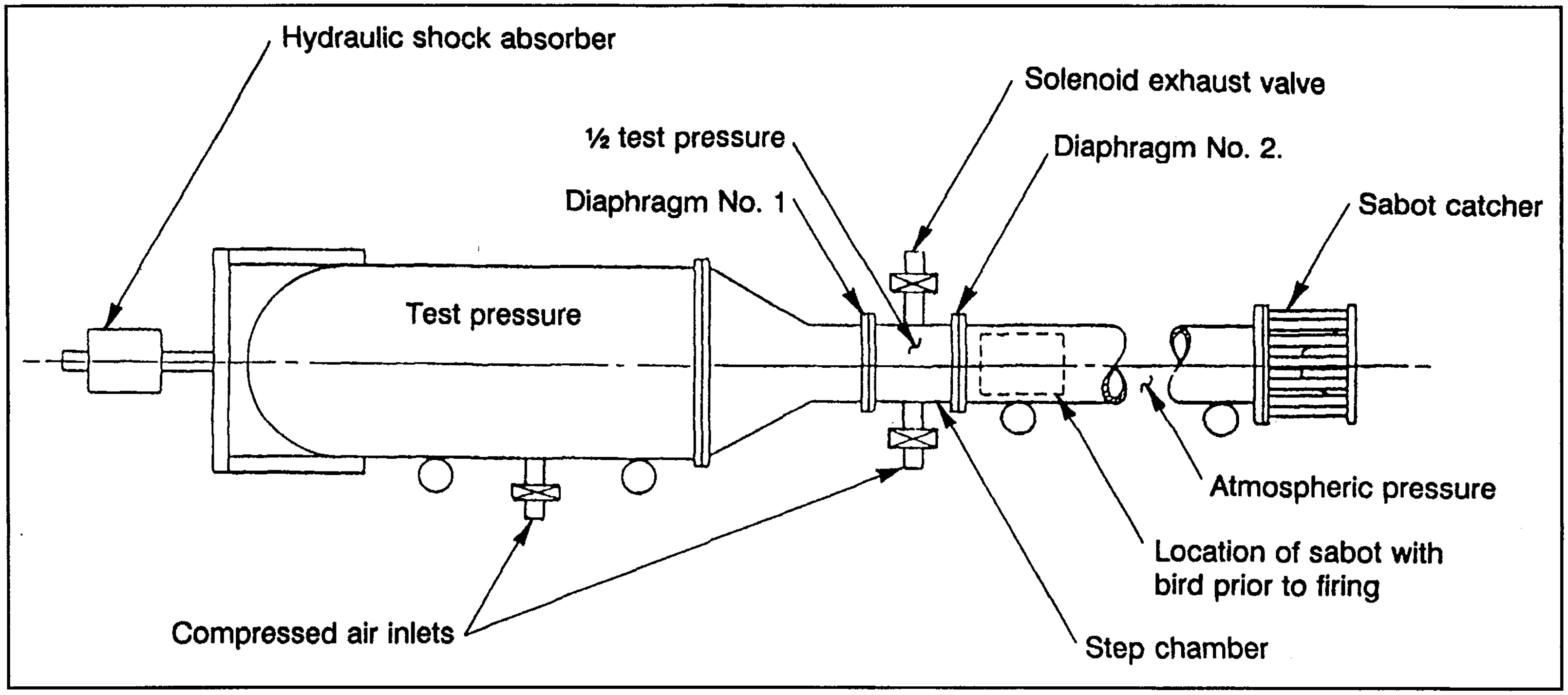


Figure 4.23 Schematic of the PPG Bird Cannon

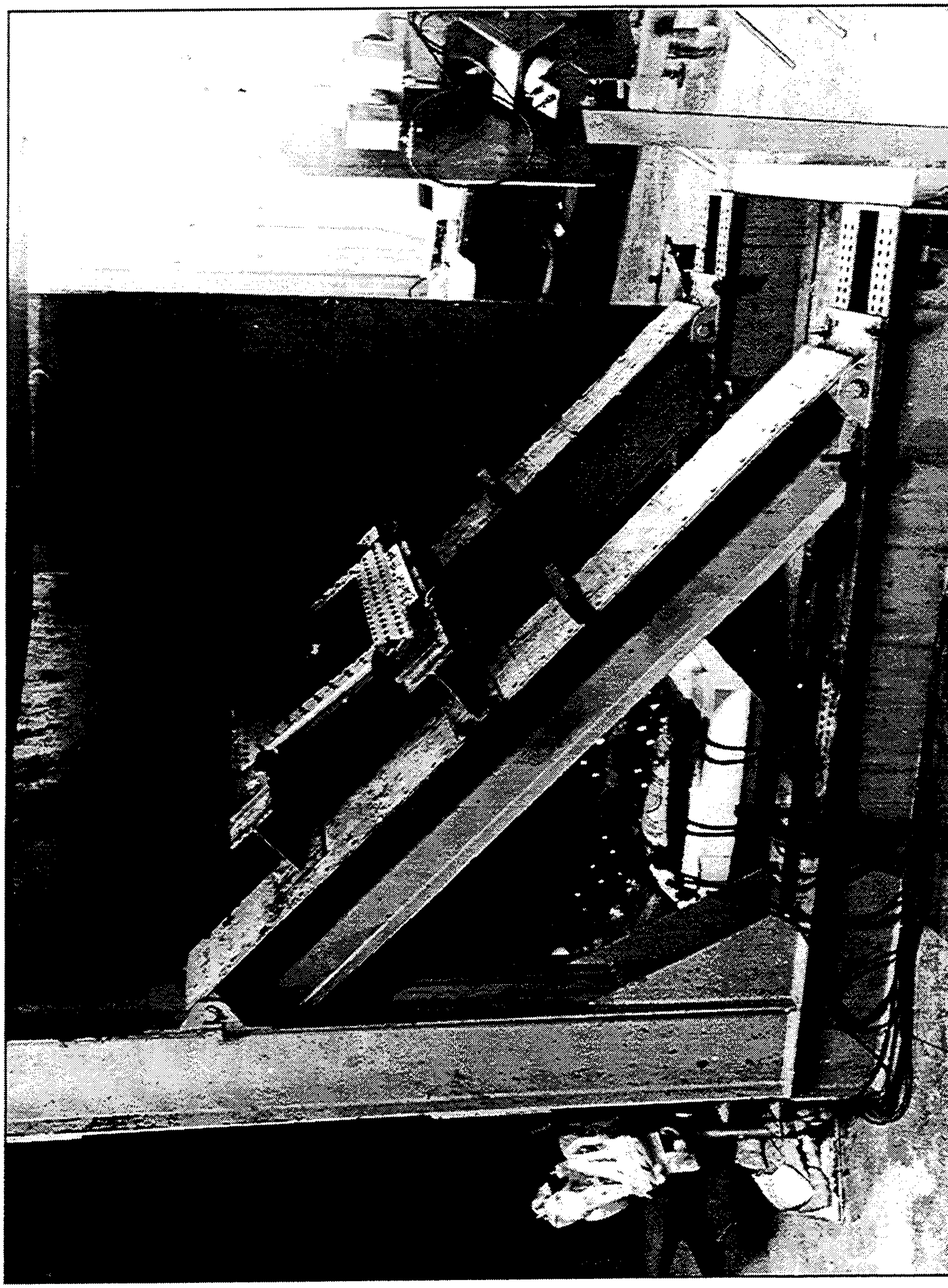


Figure 4.24 Support Frame Used for Bird Impact Testing for C/KC-135 W/WS

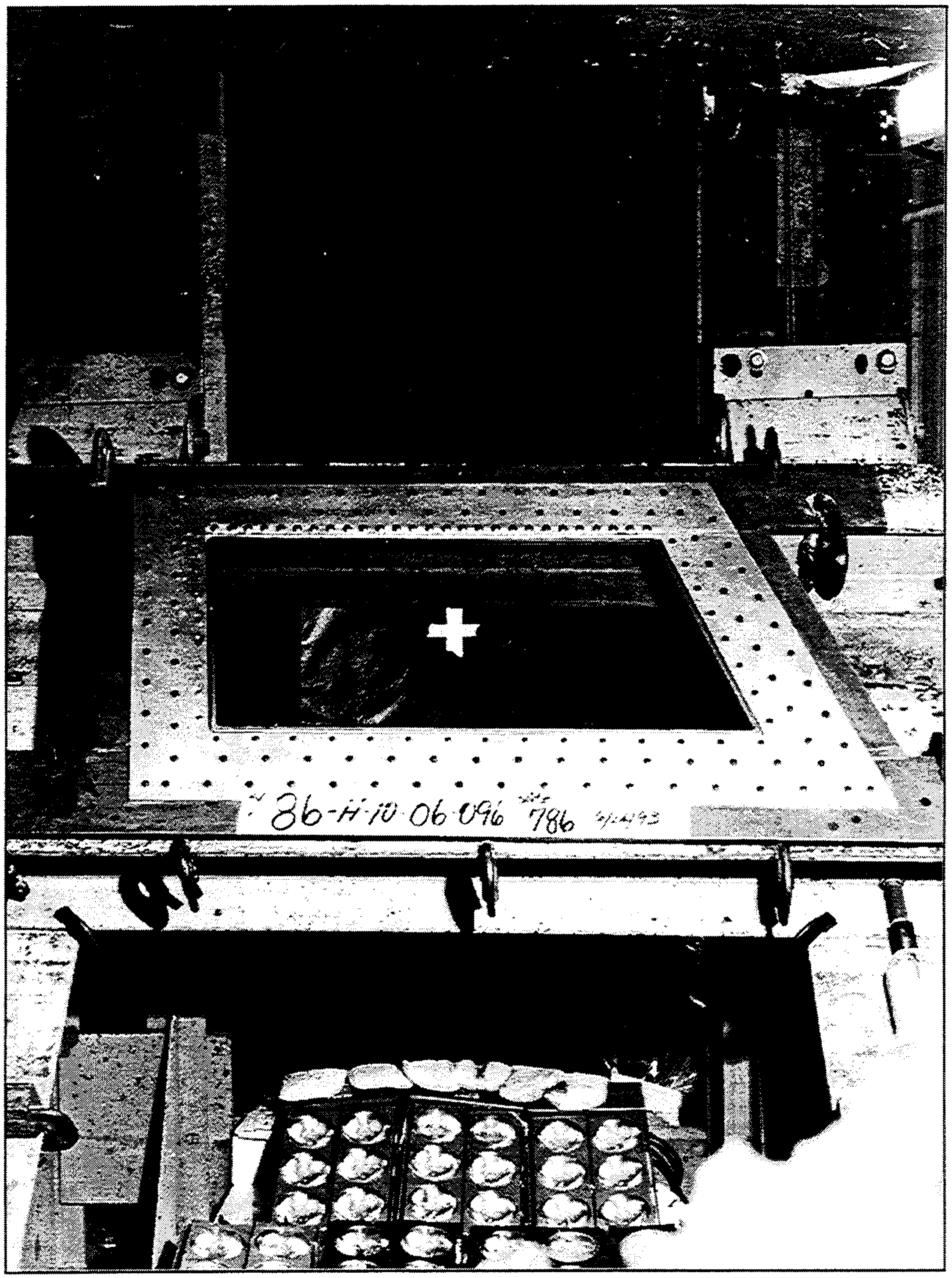


Figure 4.25 Typical Pre-Test View of C/KC-135 #1 W/WS (Copilot) Prior to Bird Impact Testing

Figure 4.26 Typical Pre-Test View of C/KC-135 #4 W/WS (Pilot) Prior to Bird Impact Testing

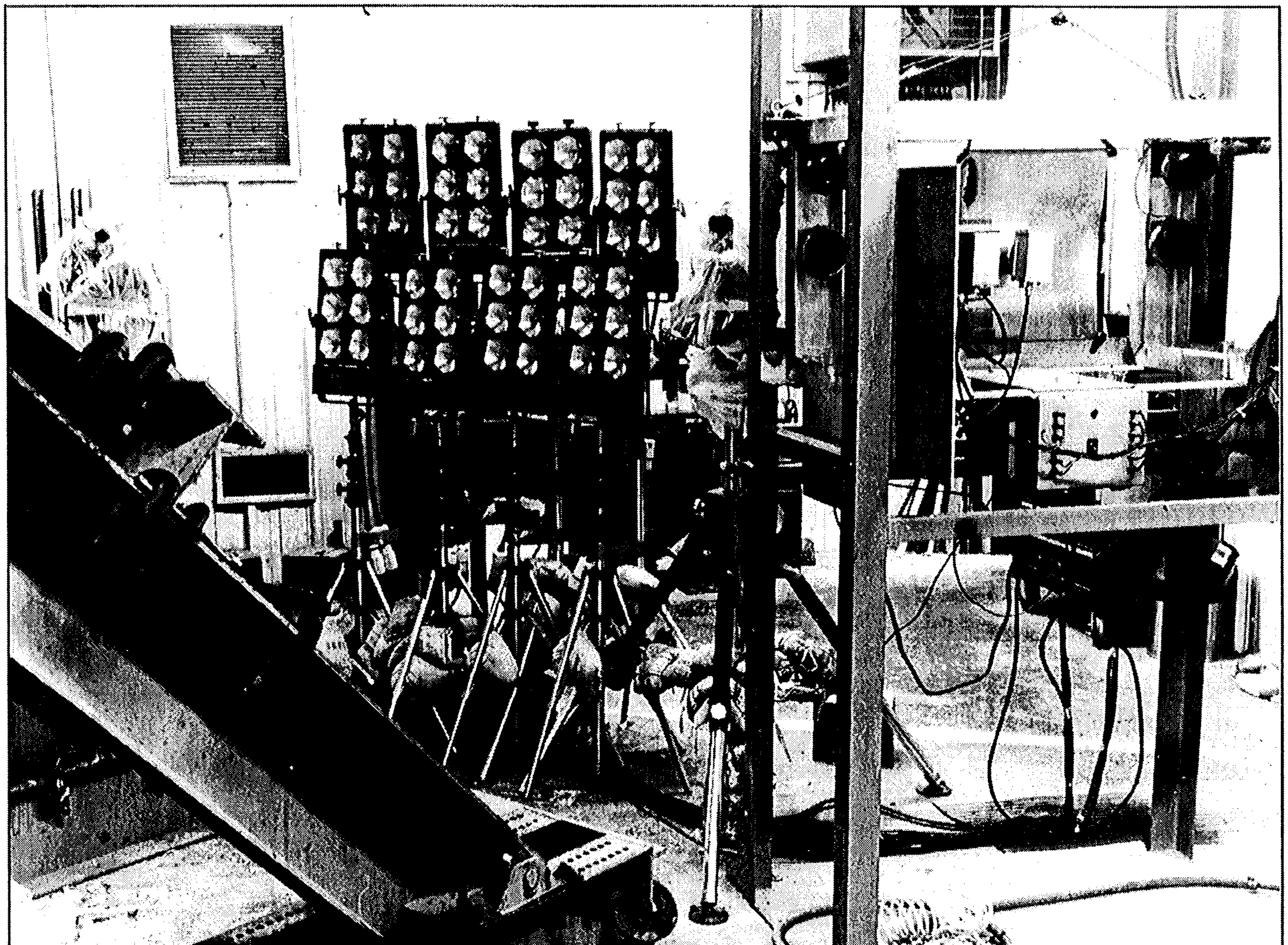


Figure 4.27 Bird Impact Test Set Up Showing Impact Velocity Timing Trap (Right) and Front High Speed Film Camera Equipment (Center)

Figure 4.28 Bird Impact Spall Sheet Viewed From Behind a C/KC-135 #1 W/WS

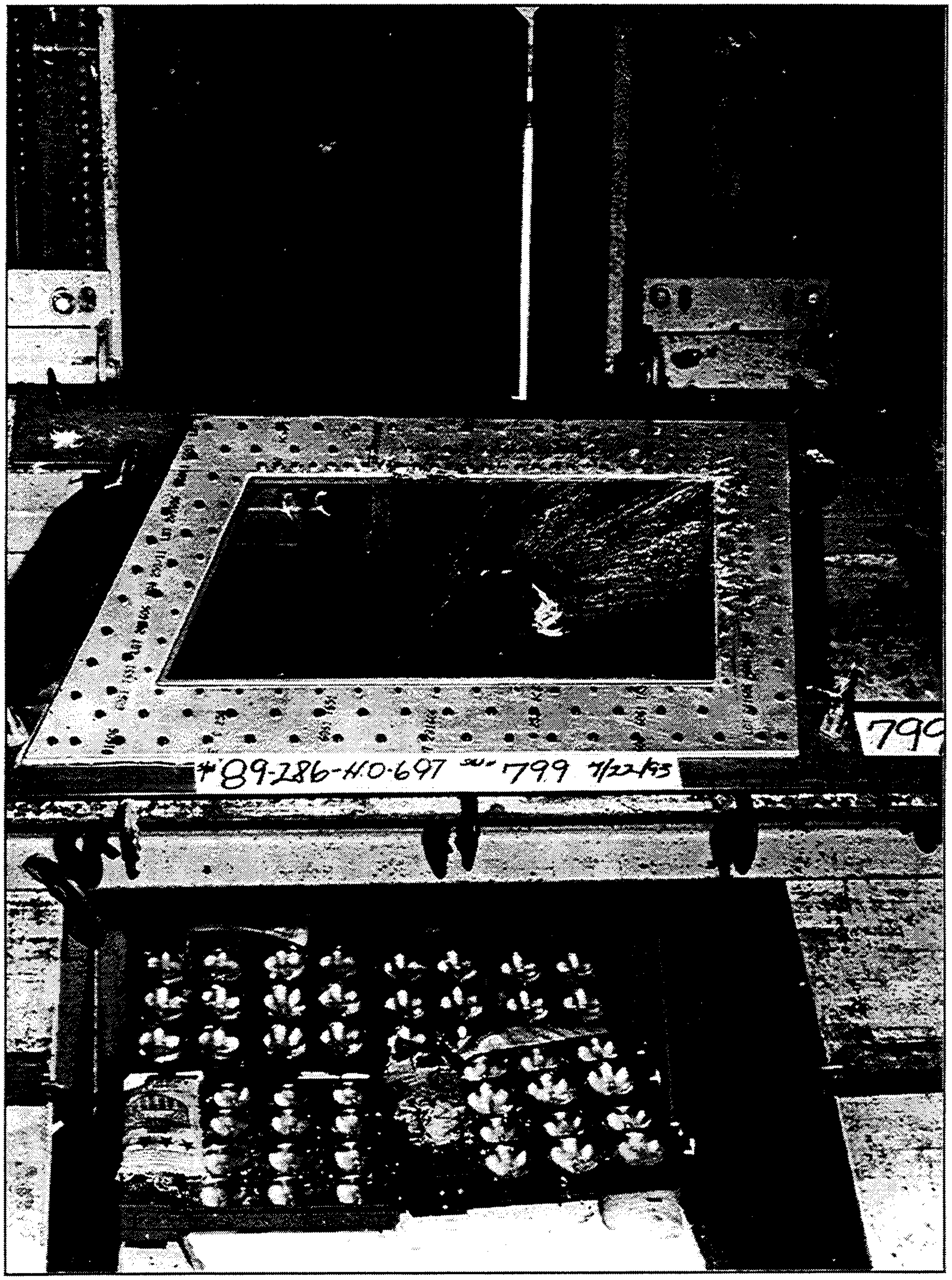


Figure 4.29 C/KC-135 #1 W/WS Showing No Damage From a 4-Pound Bird Impact at 250.8 Knots (Repaired W/WS, S/N 89-286-HO-697)

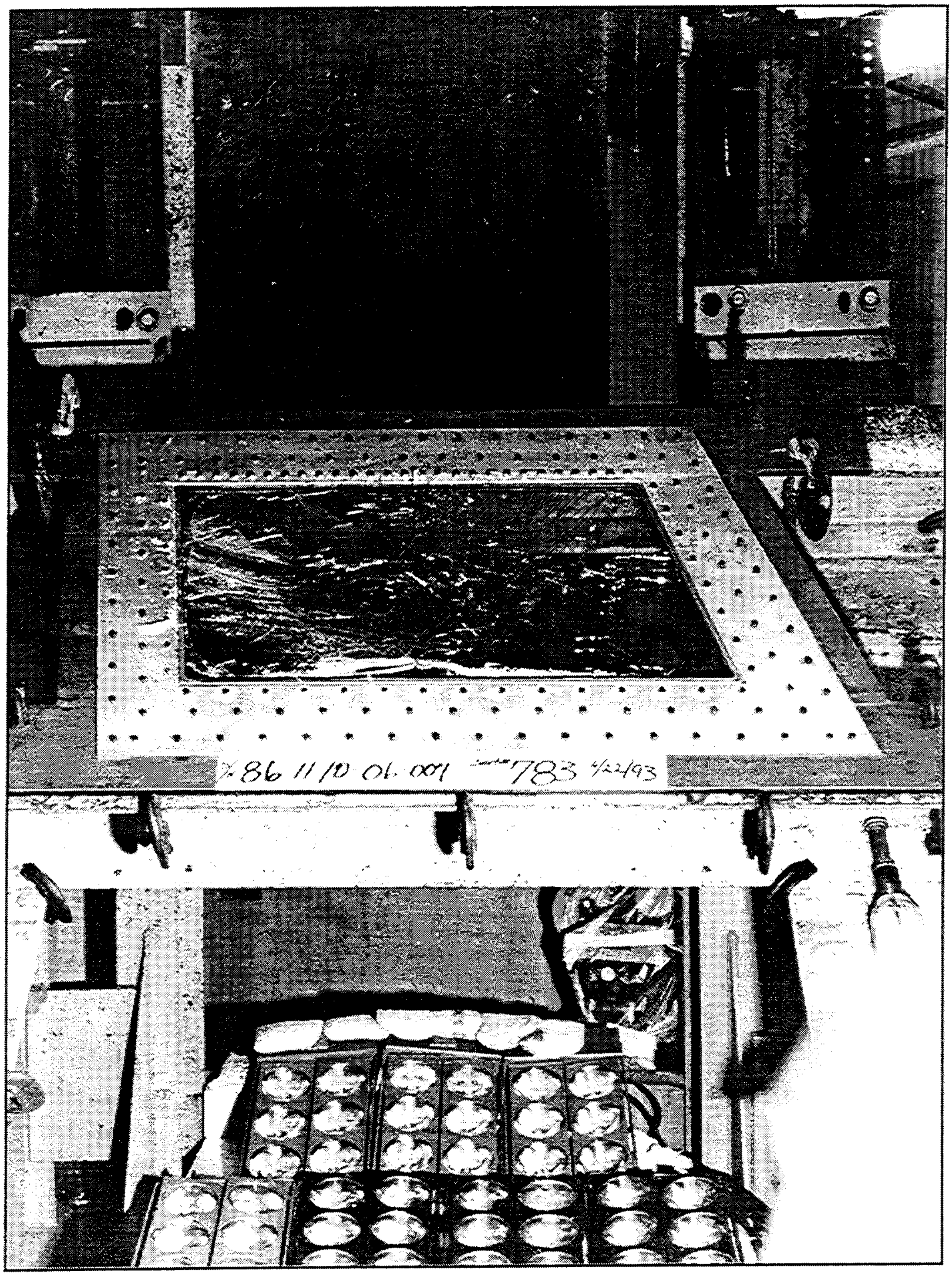


Figure 4.30 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Front View (New W/WS, S/N 86-H-10-06-007)

Figure 4.31 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Rear View (New W/WS, S/N 86-H-10-06-007)

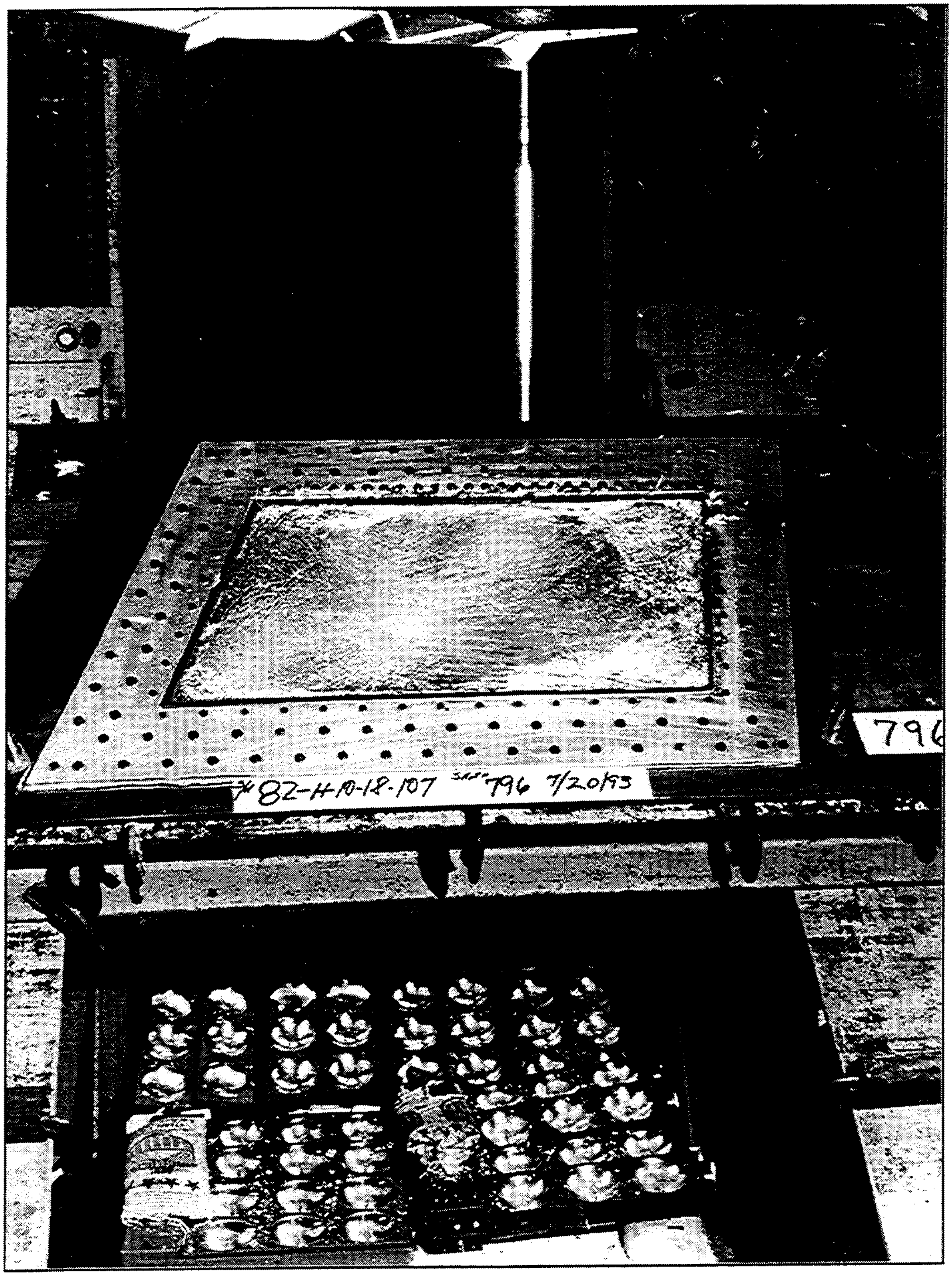


Figure 4.32 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Front View (Repaired W/WS, S/N 82-H-10-18-107)

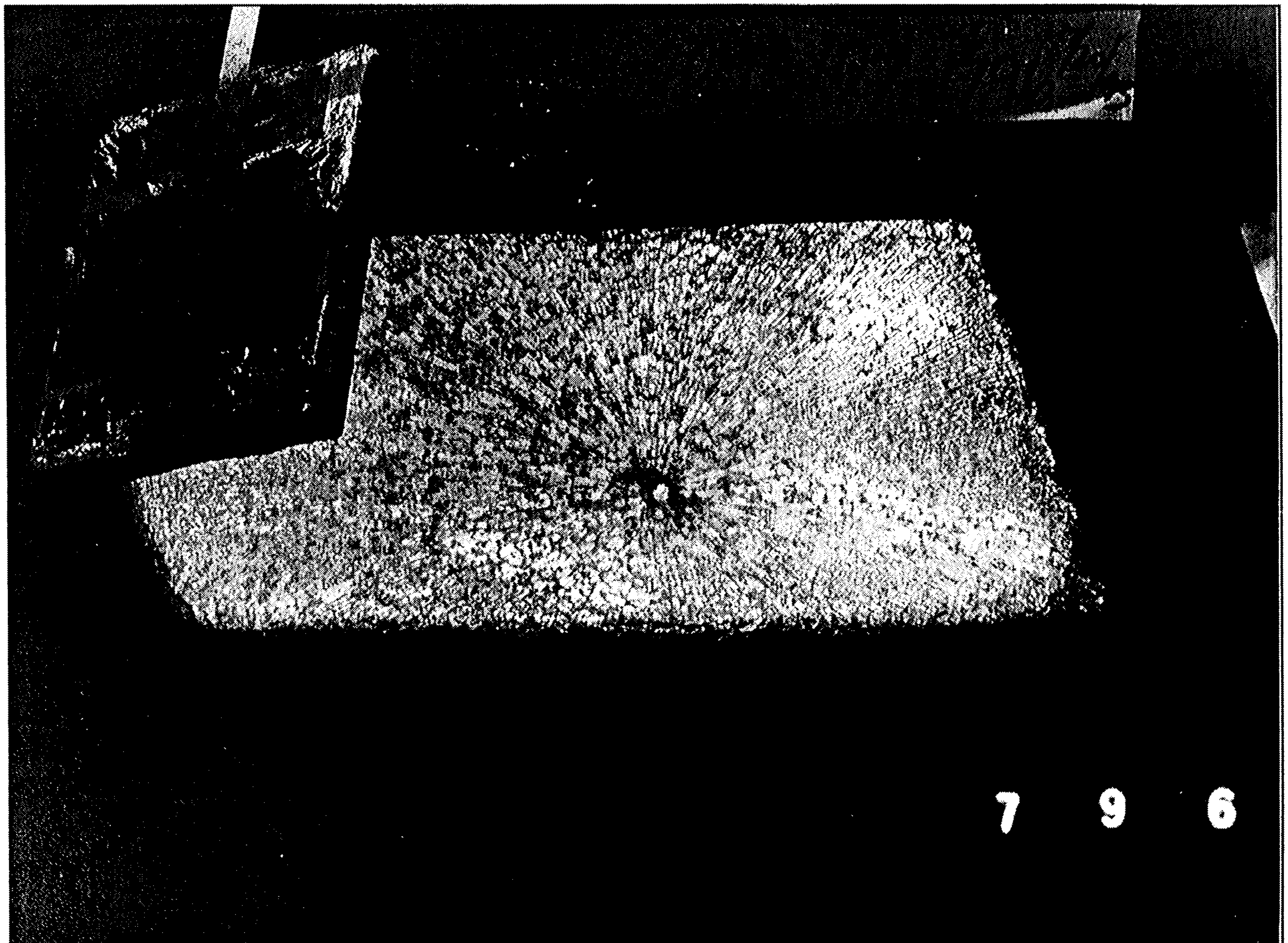


Figure 4.33 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Rear View (Repaired W/WS, S/N 82-H-10-18-107)

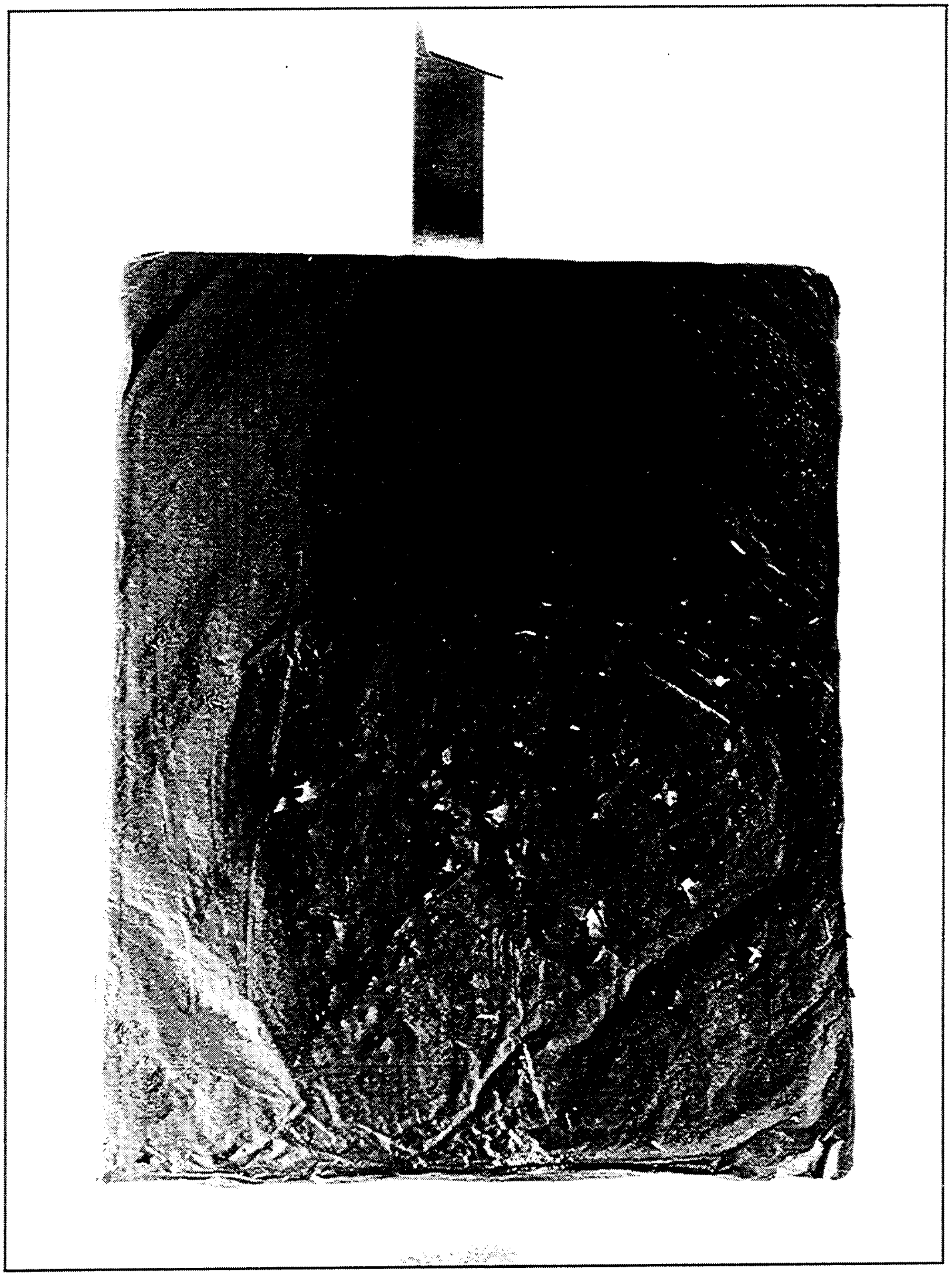


Figure 4.34 Spall Sheet Condition From a 4-Pound Bird Impact at 249.4 Knots on a C/KC-135 #1 W/WS With All Glass Plies Failed (Repaired W/WS, S/N 82-H-10-18-107)

Figure 4.35 C/KC-135 #4 W/WS Showing No Damage From a 4-Pound Bird Impact at 248.7 Knots (Not Repaired W/WS, S/N 4-H-10-9-69)

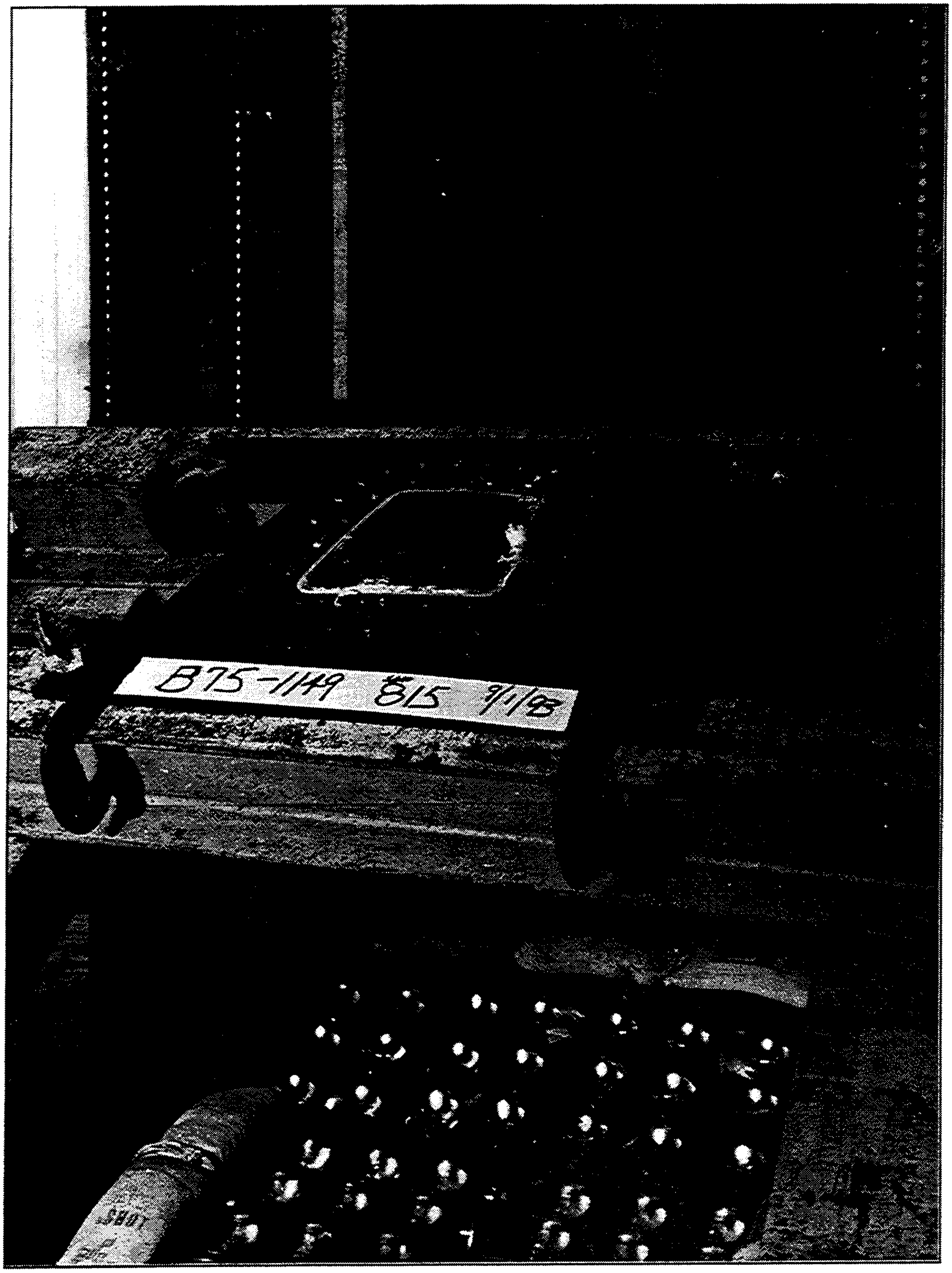


Figure 4.36 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Front View (Repaired W/WS, S/N B75-1149)

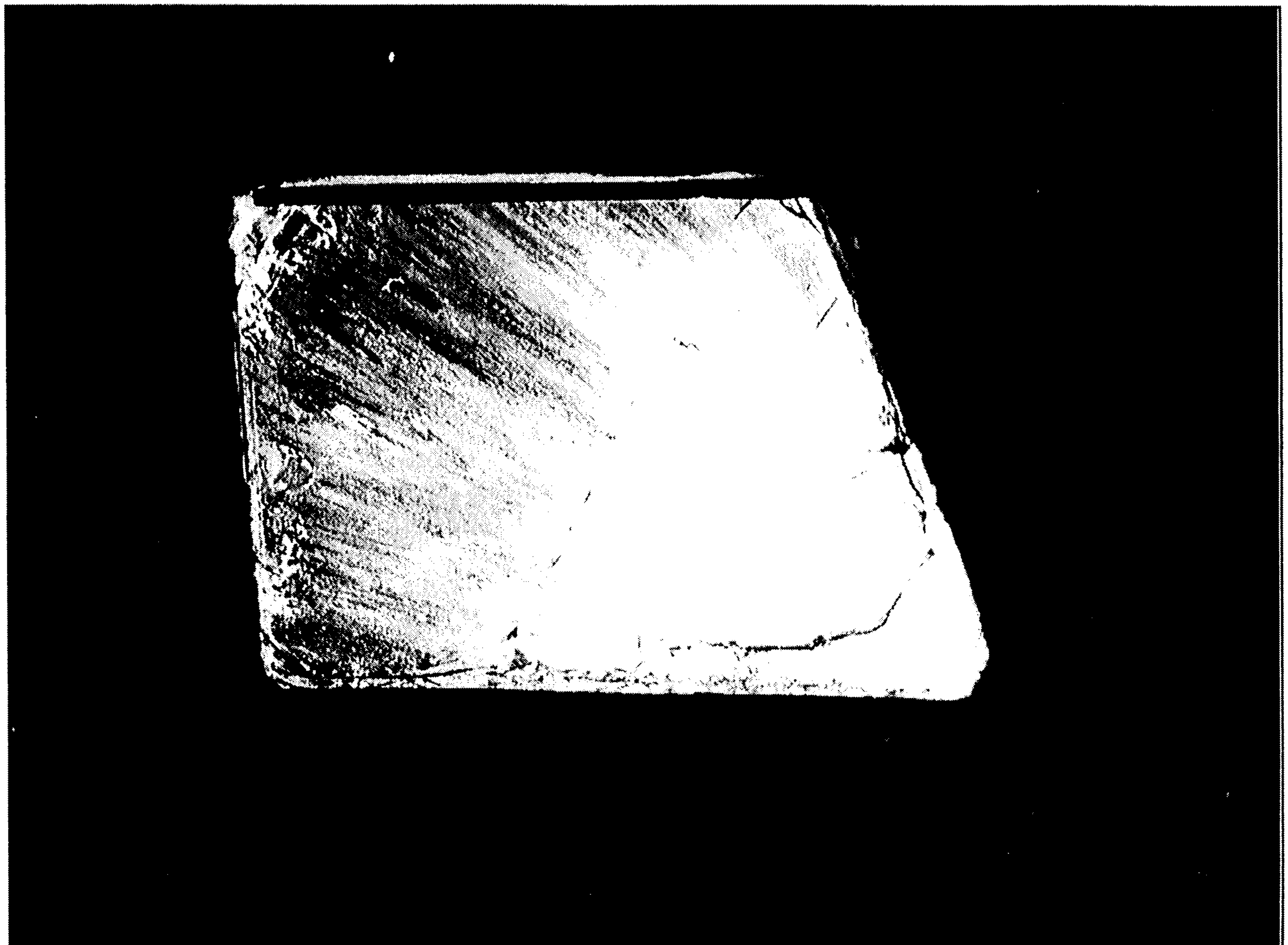


Figure 4.37 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Rear View (Repaired W/WS, S/N B75-1149)

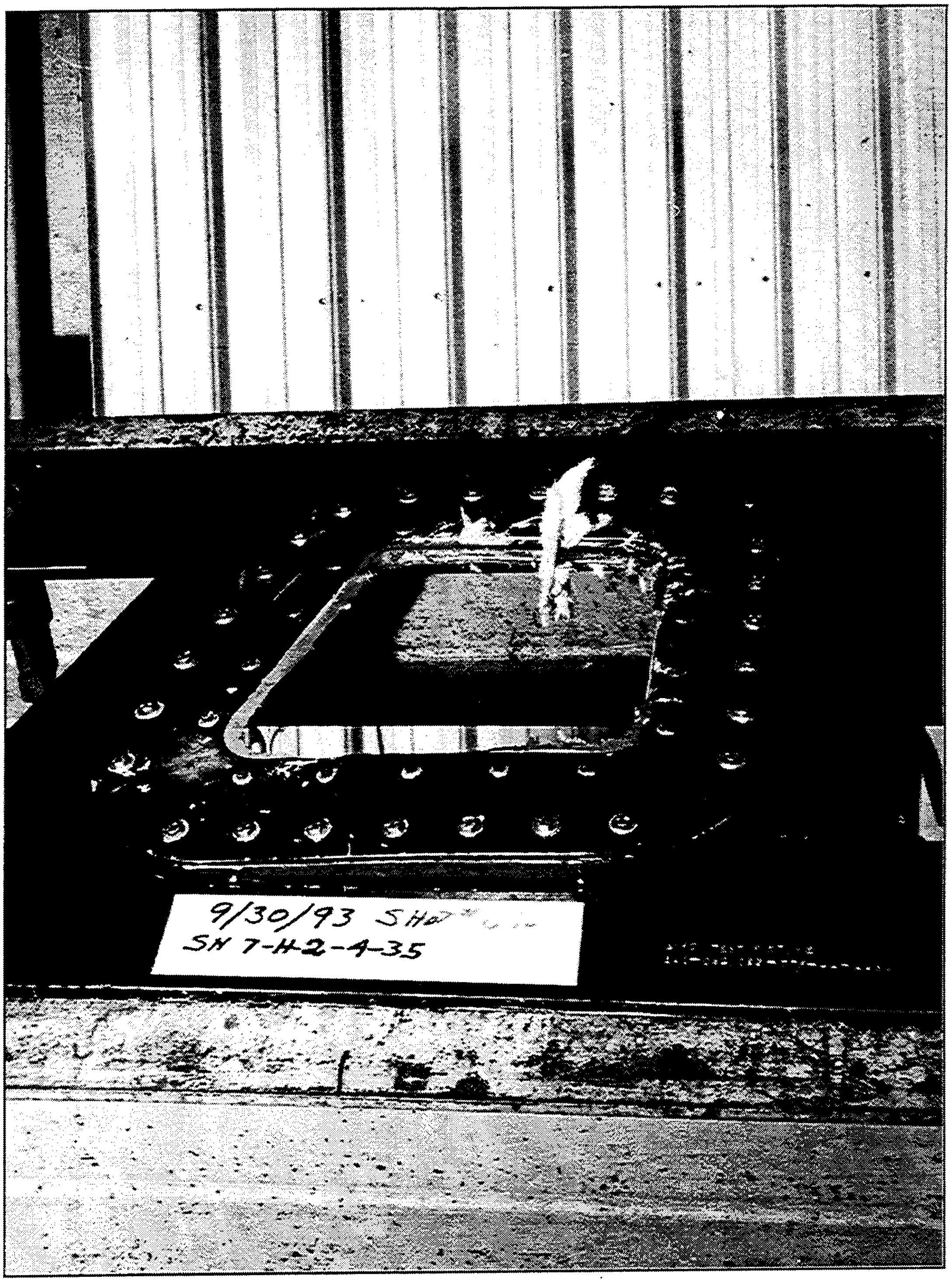


Figure 4.38 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Front View (Not Repaired W/WS, S/N 7-H-2-4-35)

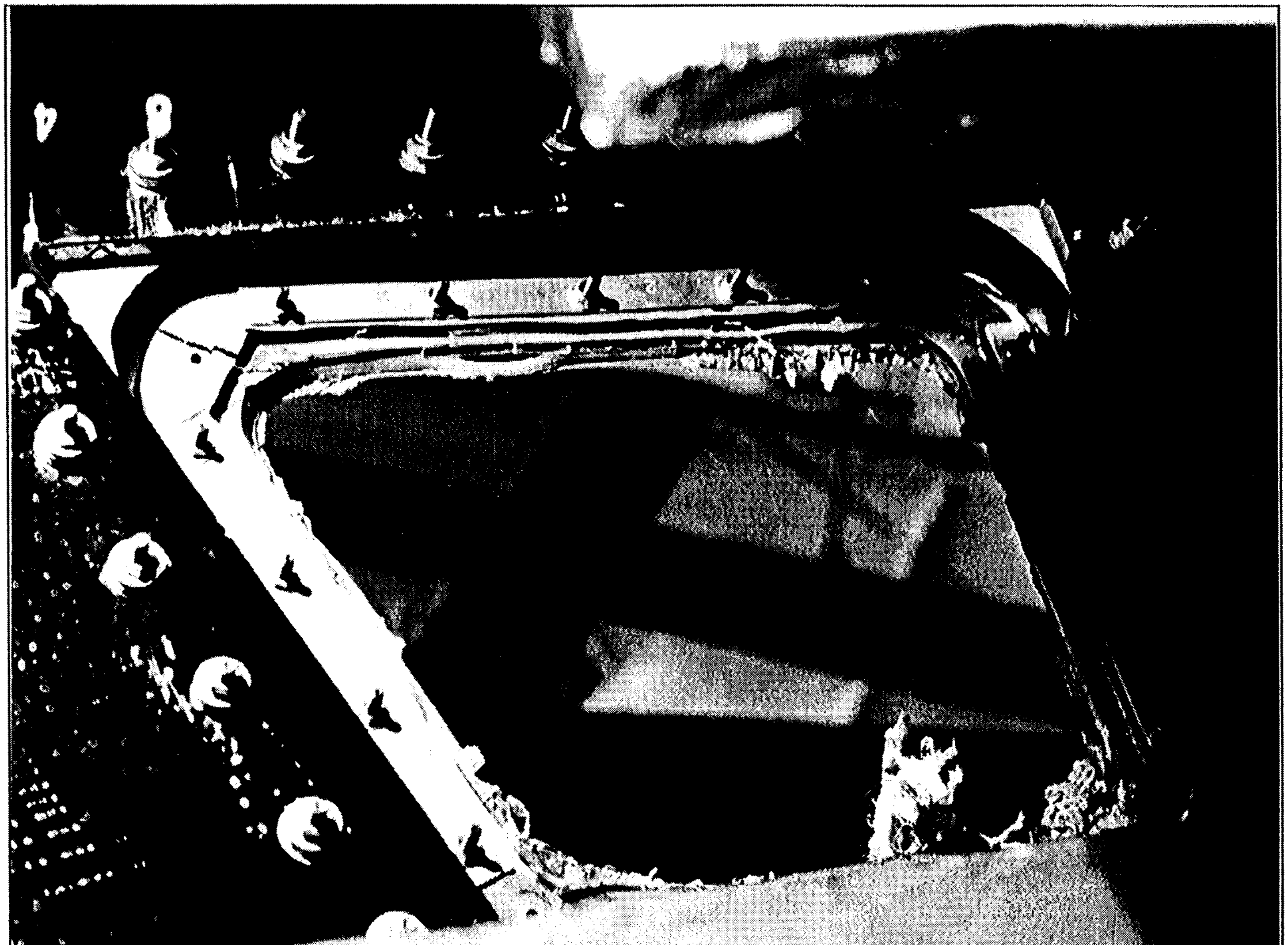


Figure 4.39 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Rear View (Not Repaired W/WS, S/N 7-H-2-4-35)

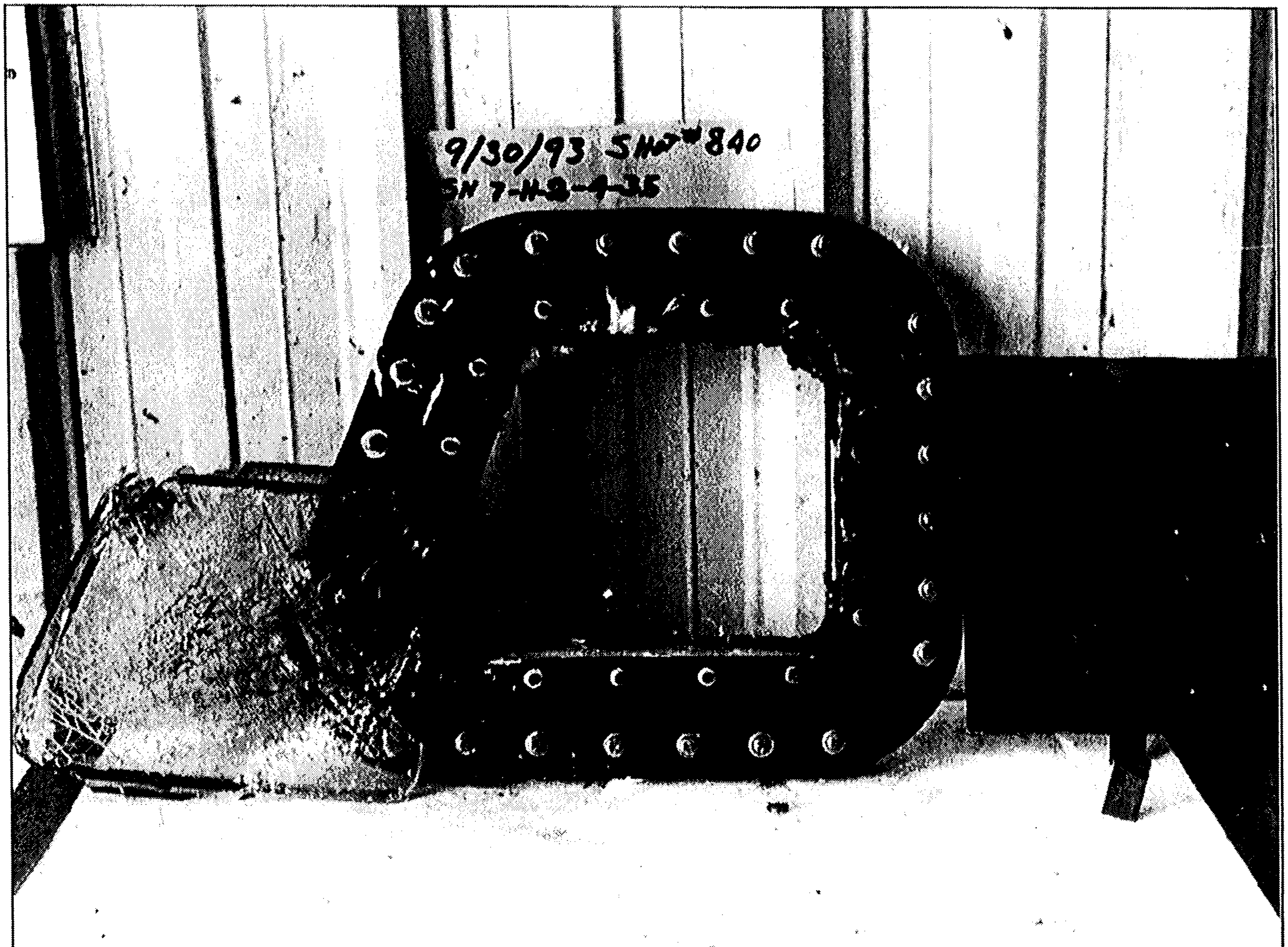


Figure 4.40 Spall Sheet and W/WS Condition From a Catastrophic 4-Pound Bird Impact at 250.8 Knots on a C/KC-135 #4 W/WS (Not Repaired W/WS, S/N 7-H-2-4-35)

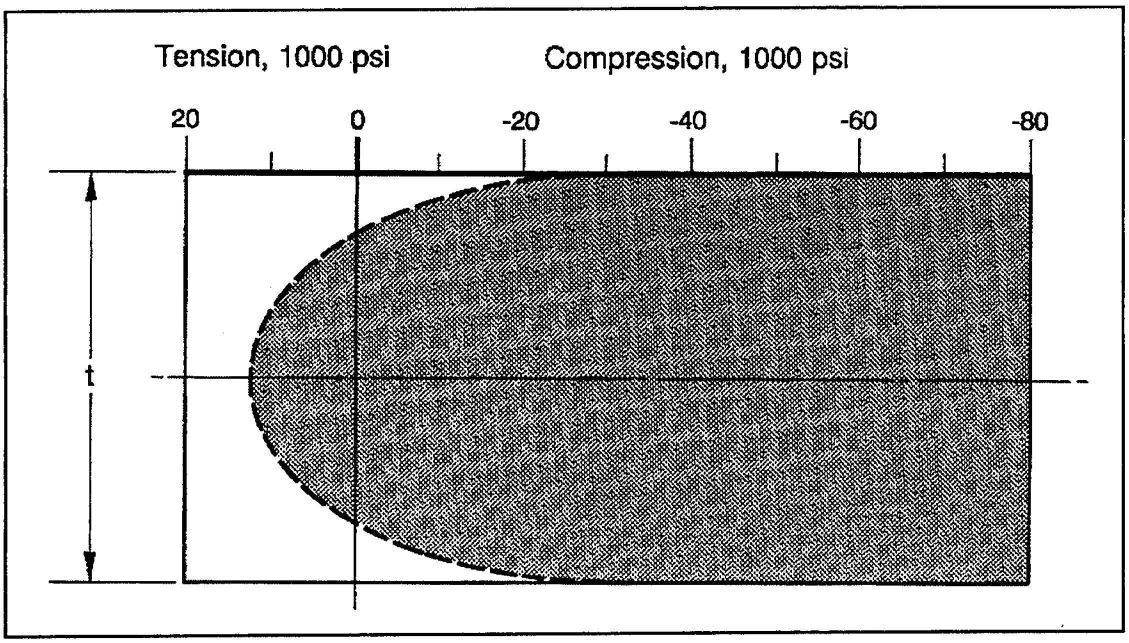


Figure 6.1 Heat Strengthened Glass Residual Stresses

APPENDIX A
REPAIR VENDOR AIR AGENCY CERTIFICATES

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number EZ22812K

This certificate is issued to
NORDAM TRANSPARANCIES DIVISION
whose business address is
510 S. LANSING
TULSA, OKLAHOMA 74120

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved REPAIR STATION

with the following ratings:
LIMITED - SPECIALIZED SERVICE

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY

By direction of the Administrator

Date issued:
February 21, 1990

Harold D. Wright
HAROLD D. WRIGHT
ACTING MANAGER, SW-FSDO-15

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number EZ22812K *is / are limited to the following:*

LIMITED RATING:

Specialized Service	Transparency inspection and repair in accordance with Aircarrier Engineering Orders, O.E.M Manuals, and NR 0101-301.

Delegated authorities: None

Date issued or revised: July 3, 1990

For the Administrator:

ROY G. WIEDEN
PRINCIPAL MAINTENANCE INSPECTOR
ASW-FSDO-15

FAA Form 8000-4-1 (1-73) FORMERLY FAA FORM 390.1 PAGE 2

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number JKQR257L

This certificate is issued to
PERKINS AIRCRAFT SERVICES, INC.

whose business address is
5001 NORTH FREEWAY, SUITE B
FORT WORTH, TEXAS 76106

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved Repair Station;

with the following ratings:
LIMITED SPECIALIZED SERVICE (10-08-93)

This certificate, unless canceled, suspended, or revoked, shall continue in effect indefinitely.

By direction of the Administrator

Date issued:
May 2, 1991

Kenneth D. Robinson
Acting Manager, FTW FSDO

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number JKQR257L *is/are limited to the following:*

LIMITED RATINGS:

SPECIALIZED SERVICE	Repair of aircraft windows, transparent enclosures, structural and non-structural composite panels, cores, flaps, ailerons and radomes. Above repairs will be performed in accordance with aircraft manufacturer's repair procedures, air carrier approved instructions and Perkins Aircraft Services, Inc., Process Specification PPS0001, Revision A, dated 09-15-93, as revised.

Delegated authorities: NONE

Date issued or revised:

October 8, 1993

For the Administrator Standley H. Cobb

Standley H. Cobb

PMI, FTW FSDO

FAA Form 8000–4–1 (1–75) FORMERLY FAA FORM 390.1 PAGE 2

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number OX4R430M

This certificate is issued to
THE GLASS DOCTOR

whose business address is
2390 26th AVENUE NORTH
St. Petersburg, Florida 33713

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved REPAIR STATION

with the following ratings:
LIMITED - SPECIALIZED SERVICE

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY

By direction of the Administrator

Date issued:
September 27, 1979
Replacement May 1, 1990

William J. Truebe, Manager
North Florida FSDO-15

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number OX4R430M *is/are limited to the following:*

LIMITED RATINGS:

SPECIALIZED SERVICE - Refurbish and repair aircraft plastic and glass windows, windshields, canopies, navigation light lenses, and other miscellaneous small transparencies, including nicks, chips, delamination, electrical busses and temperature sensor installation.

All inspections and rework will be accomplished in accordance with the following data as applicable to the unit being worked.

Aircraft Manufacturer's Maintenance Manuals/ Instruction.

FAA Approved process Specification, #1979 Cabin and Cockpit Windows dated 12-31-84 (as amended).

Air Carrier's Approved Specifications.

FAA Advisory Circular 43.13-1A, Acceptable Methods, Techniques, and Practices, Chapter 9. Windshields, Enclosures and Exits.

Delegated authorities: NONE

Date issued or revised: May 1, 1990

For the Administrator:

Kenneth S. Crockett
Principal Maintenance Inspector

FAA Form 8000-4-1 (1-75) FORMERLY FAA FORM 390.1 PAGE 2

APPENDIX B
GENERAL INSPECTION DATA SHEETS

This page intentionally left blank.

KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-062

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 34.3 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:		5-23-93	22 PPG 28
S.E. Resistance: 307	Acc	5-24-93	22 PPG 28
Insulation Test (2500 VAC) Power to S.E.:	ok	MAY 25 1993	22 PPG 77
S.E. to Metal:	ok		
S.E. to S.E.:	ok		
Nesa Scratch Test (350 VAC):	ok	MAY 25 1993	22 PPG 77
Light Transmittance:	77.6	MAY 25 1993	22 PPG 77
Haze:	1.1	MAY 25 1993	22 PPG 77
Photo (Single Exposure):		MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)	Acc	5-25-93	22 PPG 28

1: 3.0 2: 2.0 3: 1.0 4: 3.0
5: 1.0 6: 2.0 7: 2.0 8: 2.0

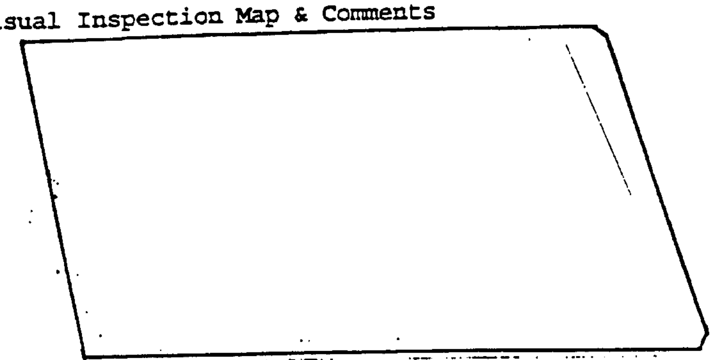
	Acc/Rej	Date	Inspector
Dimensional Inspection:		~~5-25-93~~	~~22 PPG 28~~
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.100 2: 1.102 3: 1.103 4: 1.103
5: 1.105 6: 1.104 7: 1.103 8: 1.103
9: 1.105 10: 1.105 11: 1.103 12: 1.100

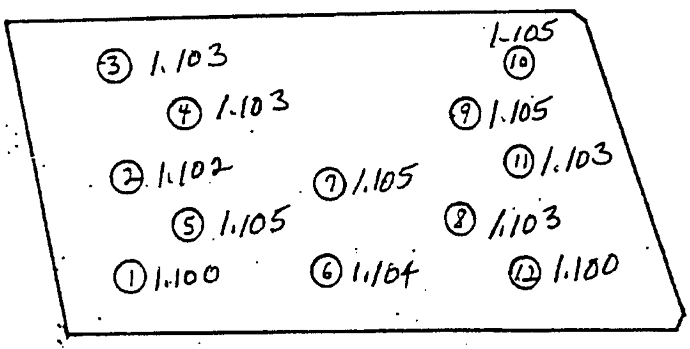
	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Acc	JUN 02 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks Acp 6-3-93 PPG 77

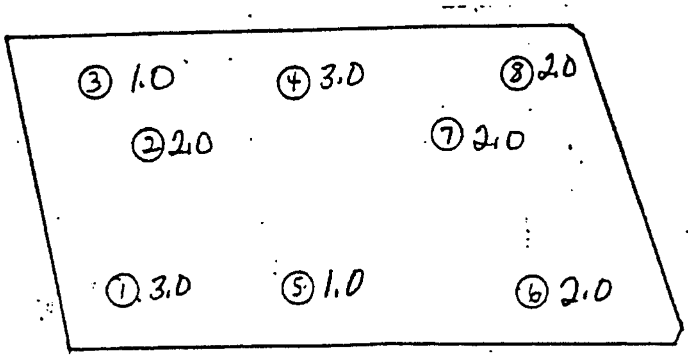
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-092

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	34.9 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	309	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	75.1 31.1	A	JUN 09 1993	22 PPG 39
Light Transmittance:	73.7	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 1.0 2: 2.0 3: 0.5 4: 1.0
5: 2.0 6: 0.5 7: 1.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-25-93	22 PPG 28

1: 1.100 2: 1.100 3: 1.100 4: 1.100
5: 1.102 6: 1.100 7: 1.105 8: 1.102
9: 1.100 10: 1.098 11: 1.102 12: 1.100

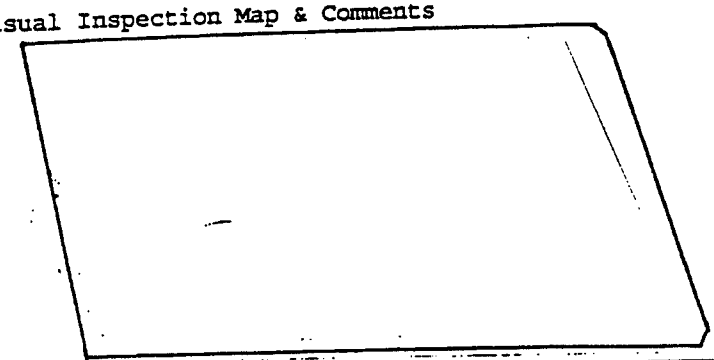
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 04 1993	22 PPG 77

(Comments) ______

Visual Inspection: (Place comments on attached sheet) — Acc — JUN 04 1993 — 22 PPG 77

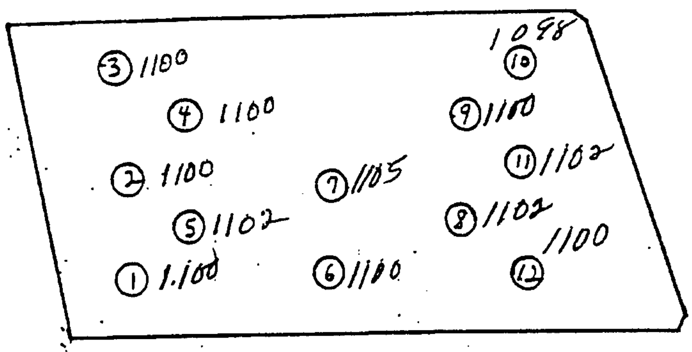
Check for vinyl cracks Aac JUN 04 1993 22 PP8 77

Visual Inspection Map & Comments

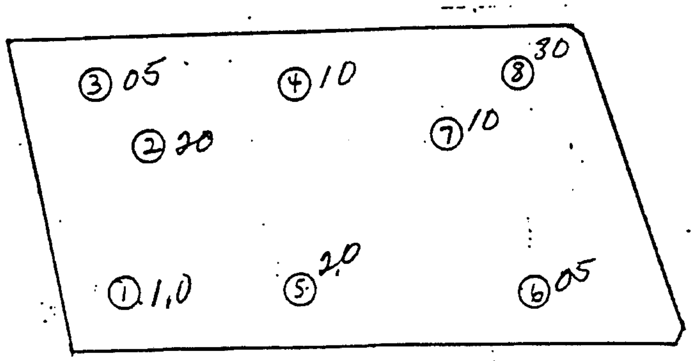


Some Air

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89364-502

Unit Serial Number: 86-4-10-06-013

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	33.8 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	314	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc OK	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc OK		
	S.E. to S.E.:	Acc OK		
Nesa Scratch Test (350 VAC):		Acc OK	MAY 25 1993	22 PPG 77
Light Transmittance:		Acc 79.7	MAY 25 1993	22 PPG 77
Haze:		Acc 1.2	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 2 · 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 2.0 3: 0.5 4: 1.0
5: 1.0 6: 1.0 7: 2.0 8: 0.5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

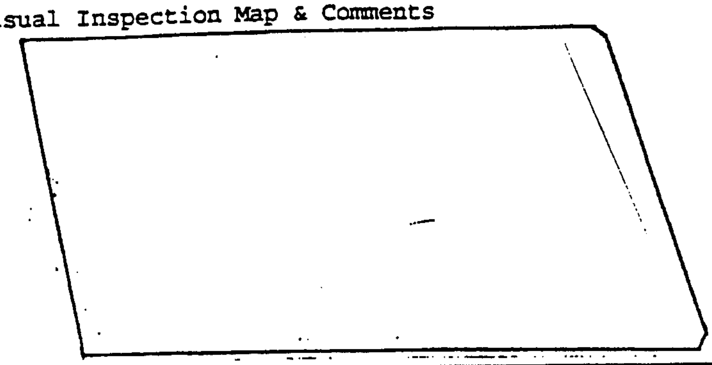
1: 1.110 2: 1.100 3: 1.095 4: 1.098
5: 1.092 6: 1.093 7: 1.094 8: 1.094
9: 1.094 10: 1.093 11: 1.091 12: 1.095

	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Acc	JUN 02 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

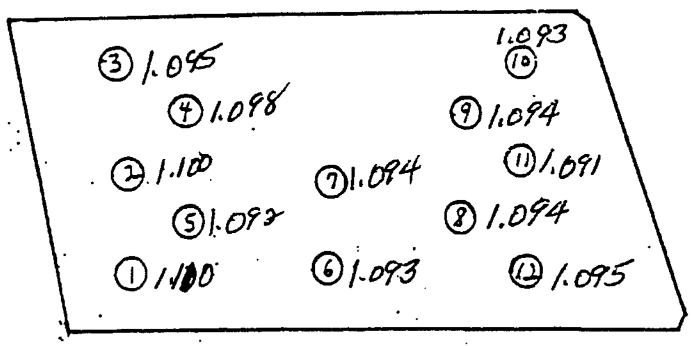
1.103
1.0

Check for vinyl cracks DCR 6-3-93 22.PPr

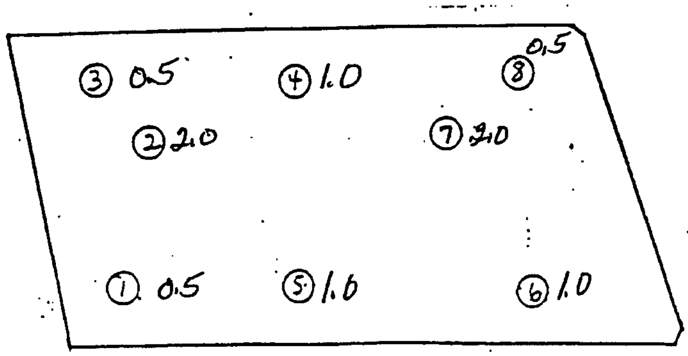
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-048

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	36.6 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	310	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	ok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	ok		
	S.E. to S.E.:	ok		
Nesa Scratch Test (350 VAC):		Ok	MAY 25 1993	22 PPG 77
Light Transmittance:		80.9	MAY 25 1993	22 PPG 77
Haze:		1.1	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		5 Acc	5-25-93	22 PPG 77

1: 2.0 2: 2.0 3: 2.0 4: 0.5
5: 1.0 6: 0.5 7: 1.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.095 2: 1.106 3: 1.093 4: 1.095
5: 1.095 6: 1.097 7: 1.102 8: 1.100
9: 1.100 10: 1.105 11: 1.097 12: 1.197

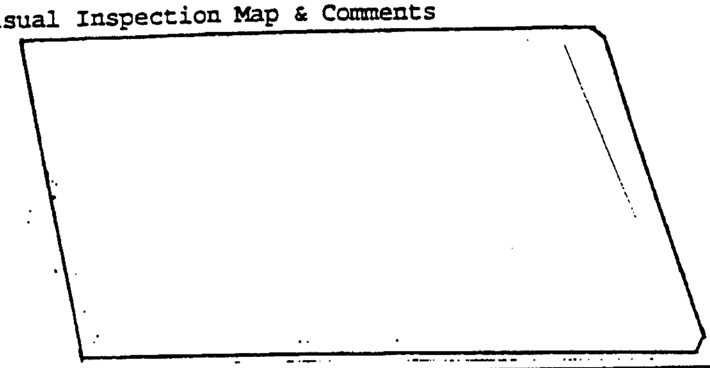
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) ______________________

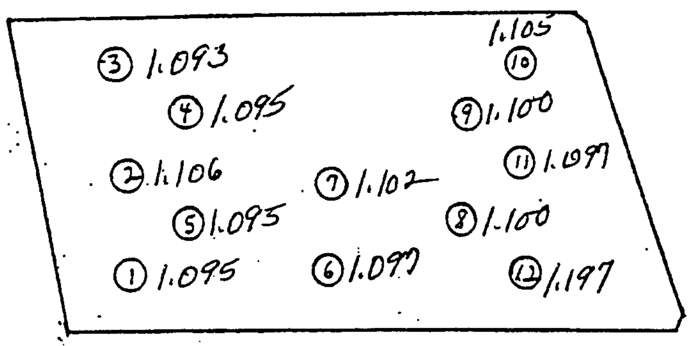
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks AOL 6-3-93 22 [illegible] 77

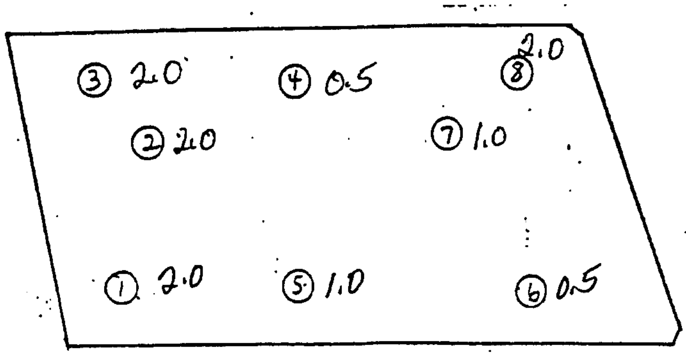
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-3096

Unit Serial Number: 83-H-11-7-432

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.0 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-26-93	22 PPG 28
S.E. Resistance:	315+315	Acc.	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	04 1993	22 PPG
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):	013	A	JUN 09 1993	22 PPG 39
Light Transmittance:	76.4	A	JUN 09 1993	22 PPG 39
Haze:	.8	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-26-93	22 PPG 22

1: 3.0 2: 2.0 3: 1.0 4: 3.0
5: 1.0 6: 1.0 7: 2.0 8: 1.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

1: 1.102 2: 1.102 3: 1.100 4: 1.101
5: 1.103 6: 1.102 7: 1.102 8: 1.102
9: 1.102 10: 1.099 11: 1.102 12: 1.098

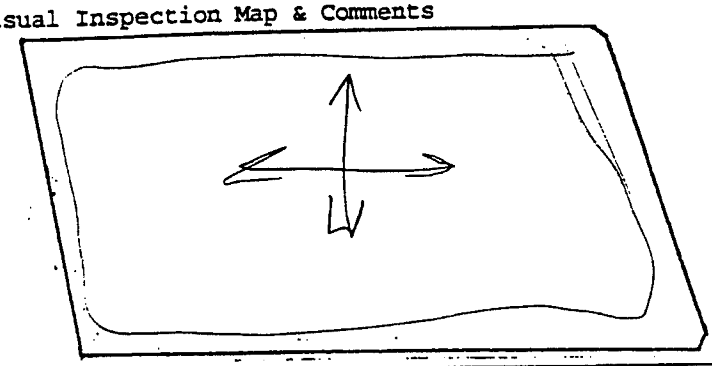
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) The seal itself looks good and bumper did flow but air and dolam. and water enter unit

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

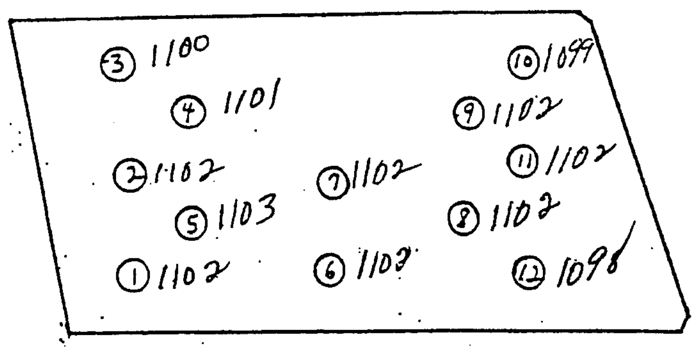
Check for vinyl cracks Asc JUN 0 4 1993 22 PP6 77

Visual Inspection Map & Comments

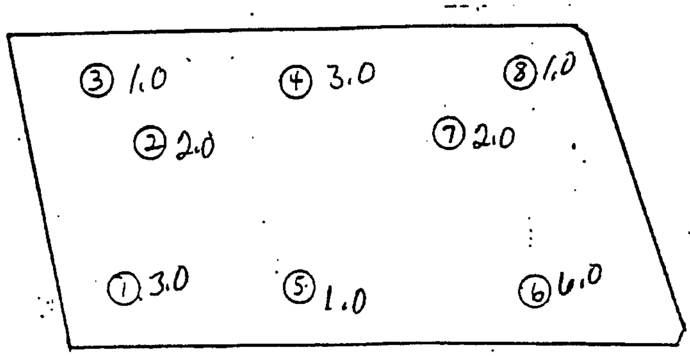


AIR, DeLAM AND WATER JUST ABOUT ALL THE WAY AROUND UNIT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-10-18-105

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	43.8 Ohms		5-21-93	22 PPG 28
Thermal Image:	3		5-20-93	22 PPG 28
S.E. Resistance:	308	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	44.5 Rei H64	A	JUN 09 1993	22 PPG 39
Light Transmittance:	75.6	A	JUN 09 1993	22 PPG 39
Haze:	.8	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993 JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-26-93	22 PPG 28

1: 1.6 2: 2.0 3: 1.0 4: 0.5
5: 2.0 6: 1.0 7: 2.0 8: 0.5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

1: 1.099 2: 1.097 3: 1.100 4: 1.100
5: 1.099 6: 1.098 7: 1.099 8: 1.099
9: 1.092 10: 1.096 11: 1.095 12: 1.095

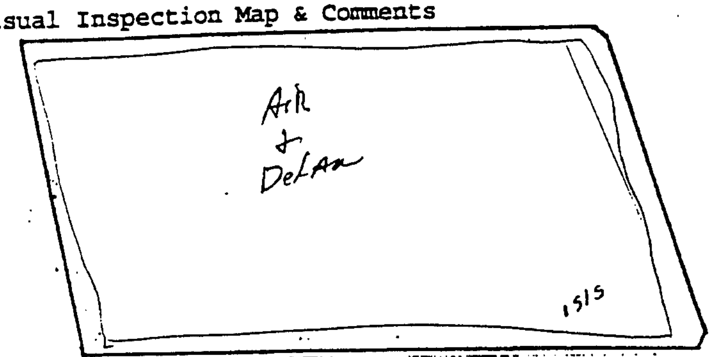
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) Seal needs to be cut too size

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

Check for vinyl cracks ACC JUN 0 4 1993 :2 PP6 77

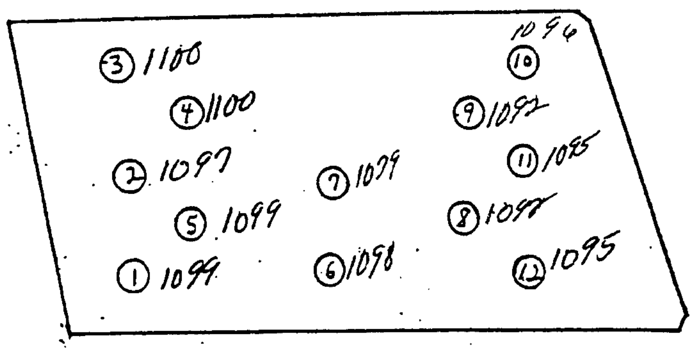
Visual Inspection Map & Comments



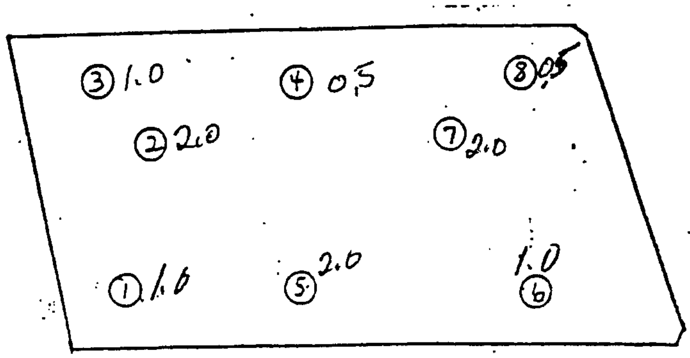
AiR & DeLAm LocAted All ARound UNiT

SuRfAce SCR LocAted BOTTom AFT Edge of UNiT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 88-H-02-08-436

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	42.8 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.308	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	42.8 Ra 74.6 H	A	JUN 09 1993	22 PPG 39
Light Transmittance:	73.6	A	JUN 09 1993	22 PPG 39
Haze:	2.3	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 0.5 3: 2.0 4: 1.0
5: 0.5 6: 0.5 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.090 2: 1.100 3: 1.100 4: 1.102
5: 1.102 6: 1.102 7: 1.102 8: 1.104
9: 1.102 10: 1.100 11: 1.104 12: 1.100

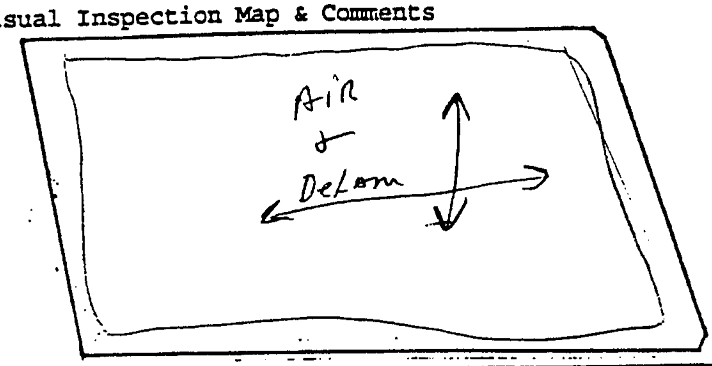
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) Seal Needs Cutting Break on Outbd Side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

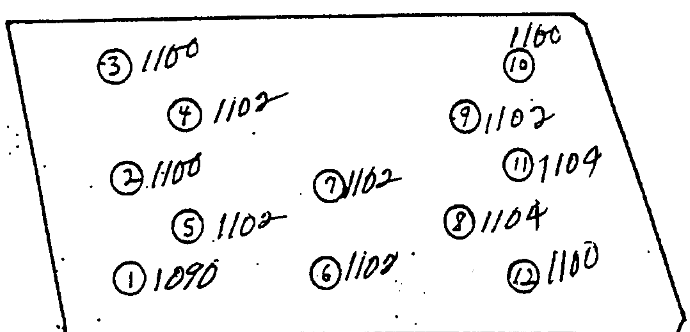
Check for vinyl cracks JUN 04 1993 PPB 77

Visual Inspection Map & Comments

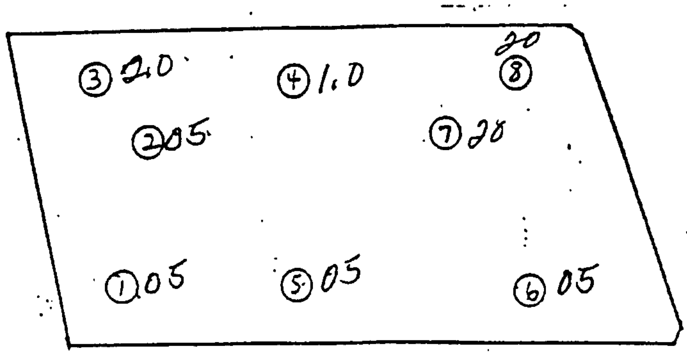


AiR And DeLAm LOCATed ALL AROUND The UNIT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-12-6-431

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	43.8 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	314	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc	MAY 25 1993	22 PPG 77
Light Transmittance:		82.5	MAY 25 1993	22 PPG 77
Haze:		1.2	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 2 8 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc.	5-24-93	22 PPG 28

1: 2.0 2: 2.0 3: 2.0 4: 2.0
5: 2.0 6: ~~2.0~~ 1.0 E.L. 7: 2.0 8: 2.0

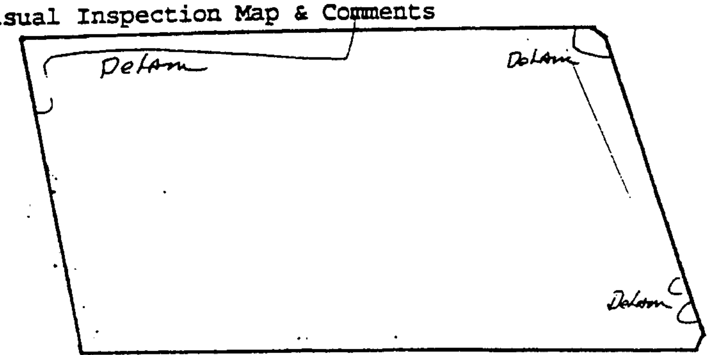
	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-24-93	22 PPG 28

1: 1.062 2: 1.063 E.L. 3: 1.063 4: 1.066
5: 1.063 6: 1.063 7: 1.067 8: 1.063
9: 1.063 10: 1.062 11: 1.062 12: 1.063

	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Acc	JUN 02 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)	ReJ	JUN 02 1993	22 PPG 77

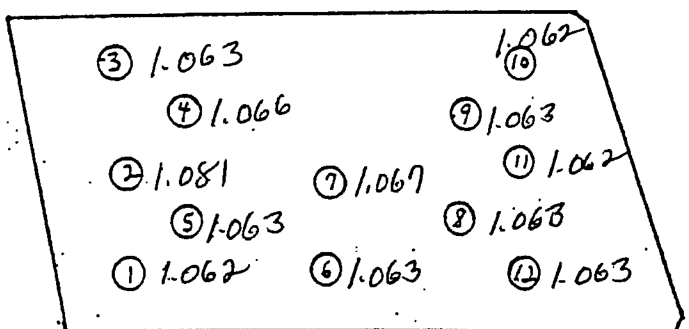
Check for vinyl cracks Aae 6-3-93 ~~22 APR 77~~

Visual Inspection Map & Comments

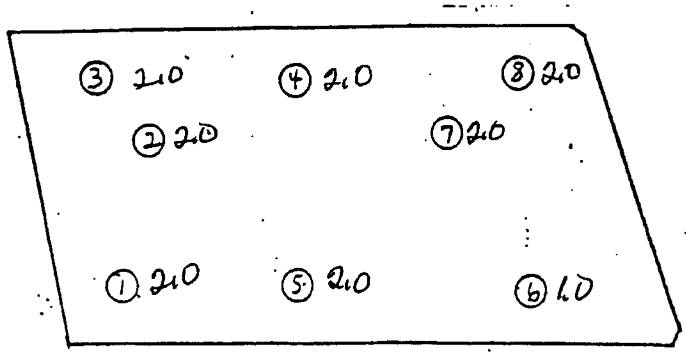


DelAm Alone TOP And Aft. Edge of Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 1-H-10-5-480

	Acc/Rej	Date	Inspector
✓ Bus to Bus Resistance: 42.2 Ohms		5-21-93	22 PPG 28
✓ Thermal Image:		5-19-93	22 PPG 28
✓ S.E. Resistance:	Acc	5-24-93	[illegible]
Insulation Test: (2500 VAC) Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
S.E. to Metal:	Acc		
S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):	Acc	MAY 25 1993	22 PPG 77
Light Transmittance:	82.6	MAY 25 1993	22 PPG 77
Haze:	1.2	MAY 25 1993	22 PPG 77
Photo (Single Exposure):		MAY 26 1993	22 PPG 4
✓ Deviation Inspection: (German Light per Template)	Acc	5-24-93	[illegible]

1: 2.0   2: 3.0   3: 2.0   4: 2.0
5: 0.5   6: 0.5   7: 1.0   8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
✓ Unit Thickness: (Per Template)	Acc	5-24-93	[illegible]

1: 1.103   2: 1.104   3: 1.105   4: 1.105
5: 1.108   6: 1.104   7: 1.109   8: 1.104
9: 1.104   10: 1.105   11: 1.108   12: 1.105

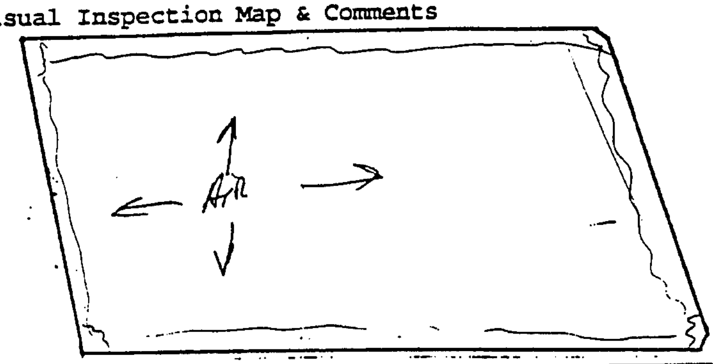
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments)
wrong seal on outBd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 02 1993	22 PPG 77

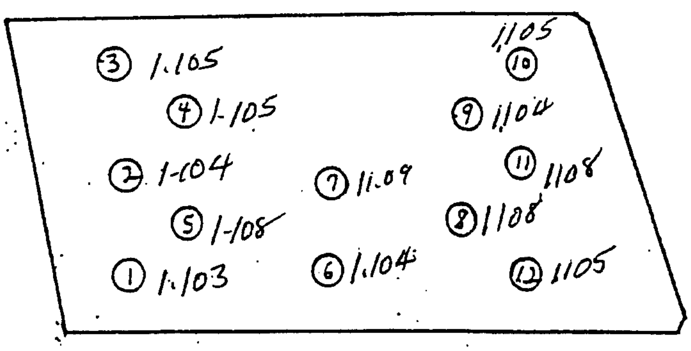
Check for vinyl cracks Acc 6-3-93 PPG 77

Visual Inspection Map & Comments

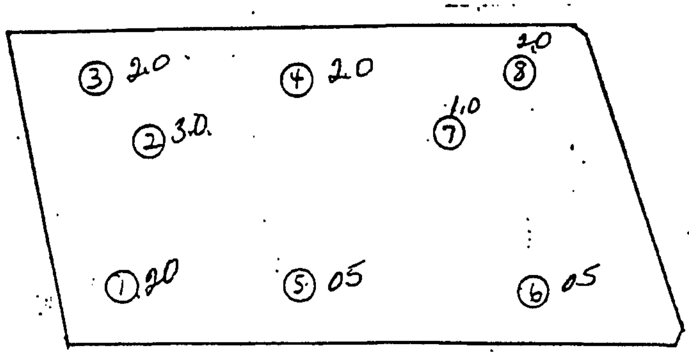


Air All Along The edge of unit.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-9-19-294

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	50.8 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.314	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	PG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	0165 5/5 5.2 L N/S	Limit Rej	JUN 09 1993	22 PPG 39
Light Transmittance:	77.0	A	JUN 09 1993	22 PPG 39
Haze:	1.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 EPG 28

1: 2.0 2: 2.0 3: 2.0 4: 1.0
5: 2.0 6: 2.0 7: 3.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 EPG 28

1: 1.099 2: 1.099 3: 1.099 4: 1.100
5: 1.104 6: 1.106 7: 1.105 8: 1.102
9: 1.103 10: 1.102 11: 1.102 12: 1.096

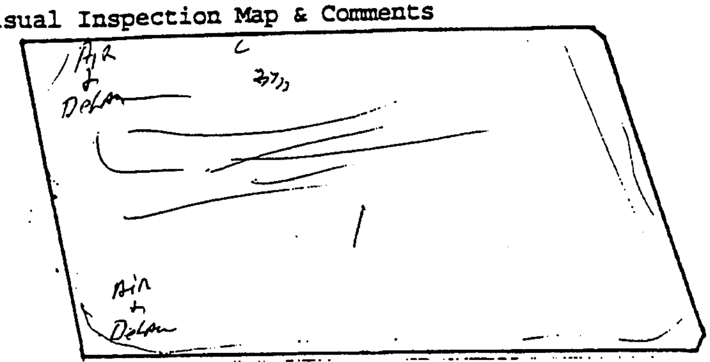
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) UNIT APPEARS TO BE Coming apart

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

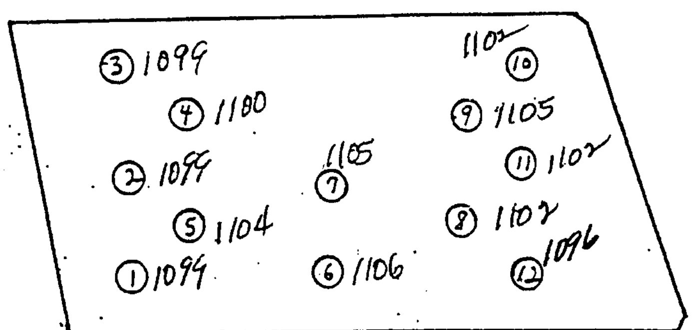
Check for vinyl cracks Res JUN 04 1993 22 pPs 77

Visual Inspection Map & Comments

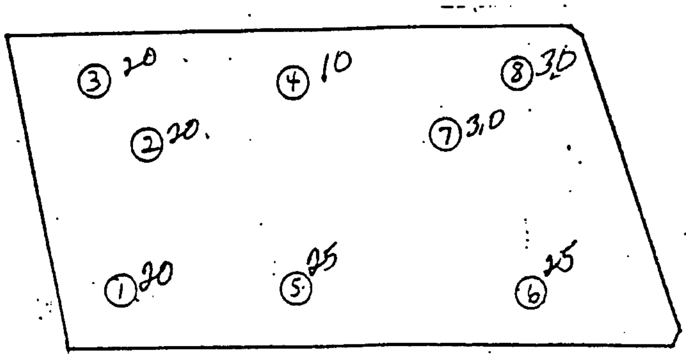


AIR And DeLam AROUND The unit.
Surface ~~ER~~ ALL over The outer side of unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-9-6-537

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	H2.1 Ohms		5-21-93	22 PPS 28
Thermal Image:			5-20-93	22 PPS 28
S.E. Resistance:	3/2	Acc	5-21-93	22 PPS 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPS 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	—		
Nesa Scratch Test (350 VAC):	43.7 Deg. HIGH	A	JUN 09 1993	22 PPS 39
Light Transmittance:	74.2	A	JUN 09 1993	22 PPS 39
Haze:	1.2	A	JUN 09 1993	22 PPS 39
Photo (Single Exposure):			JUN 14 1993	22 PPS 8
Deviation Inspection: (German Light per Template)		Acc	5-26-93	22 PPS 28

1: 0.5 2: 1.0 3: 0.5 4: 1.0
5: 2.0 6: 0.5 7: 1.0 8: 2.0

		Acc/Rej	Date	Inspector
Dimensional Inspection:				
Unit Thickness: (Per Template)		Acc	5-26-93	22 PPS 28

1: 1.124 2: 1.124 3: 1.119 4: 1.124
5: 1.126 6: 1.120 7: 1.120 8: 1.124
9: 1.120 10: 1.122 11: 1.122 12: 1.118

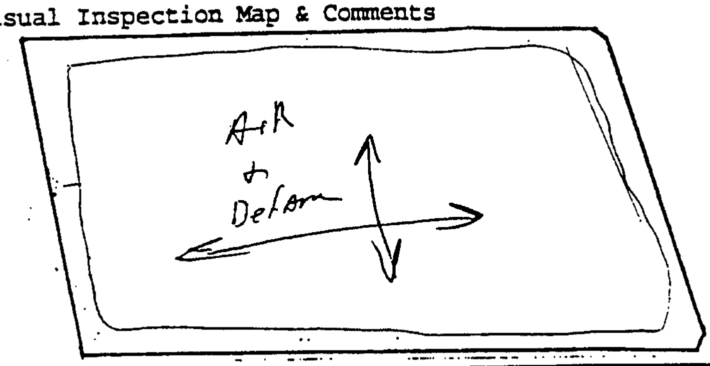
		Acc/Rej	Date	Inspector
Seal Evaluation:		Rej	JUN 04 1993	22 PPS 77

(Comments) wrong seal on outside side

		Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)		Rej	JUN 04 1993	22 PPS 77

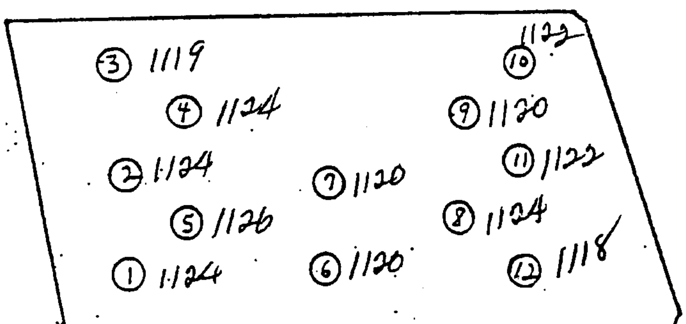
Check for vinyl cracks Acc JUN 04 1993 22 PP6 77

Visual Inspection Map & Comments

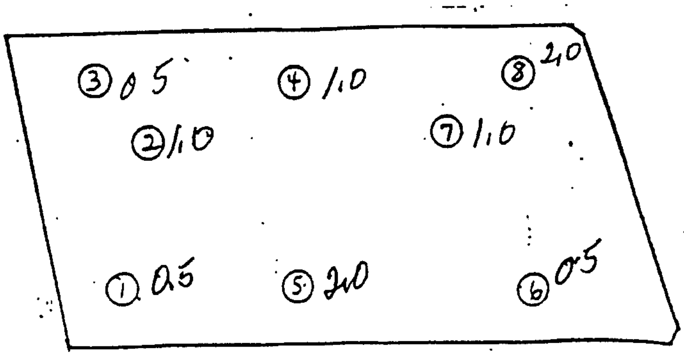


AiR + DeLam LocATed ALL ARound UNiT.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-9-19-459

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.2 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.313	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	42.3 Dist. Fwd + Aft (Sw?) center	A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.8	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 2.0 2: 1.0 3: 1.0 4: 2.0
5: 1.0 6: 0.5 7: 4.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.102 2: 1.099 3: 1.102 4: 1.101
5: 1.102 6: 1.109 7: 1.102 8: 1.102
9: 1.102 10: 1.106 11: 1.101 12: 1.100

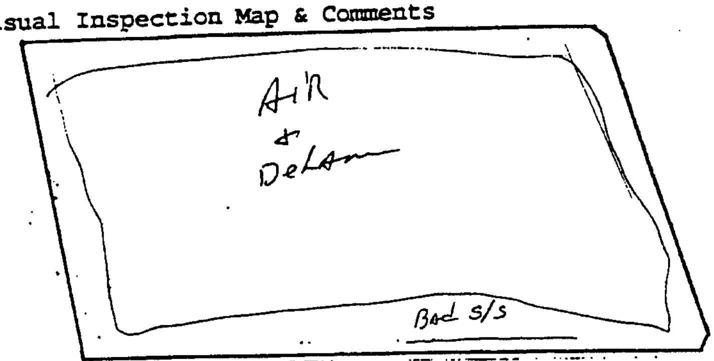
	Acc/Rej	Date	Inspector
Seal Evaluation:	Res	JUN 04 1993	22 PPG 77

(Comments)
Seal Needs cutting too size

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 04 1993	22 PPG 77

Check for vinyl cracks   ARC JUN 04 1993 22

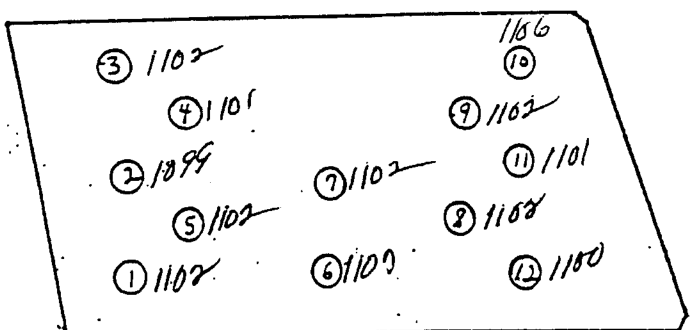
Visual Inspection Map & Comments



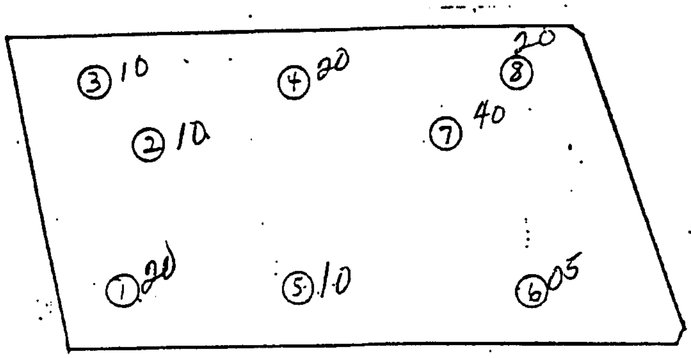
AiR & DeLam Located Around The unit.

Very Bad Surface SCR Located Bottom Fwd. Edge

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89364-502

Unit Serial Number: 86-H-10-06-007

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	37.5 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	308	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	AW ok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	AW ok		
	S.E. to S.E.:	AW ok		
Nesa Scratch Test (350 VAC):		AW ok	MAY 25 1993	22 PPG 77
Light Transmittance:		86.3	MAY 25 1993	22 PPG 77
Haze:		1.4	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 25 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 1.0 3: 3.0 4: 1.0
5: 0.5 6: 1.0 7: 2.0 8: 0.5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-25-93	22 PPG 28

1: 1.097 2: 1.095 3: 1.091 4: 1.095
5: 1.095 6: 1.094 7: 1.095 8: 1.093
9: 1.096 10: 1.097 11: 1.093 12: 1.091

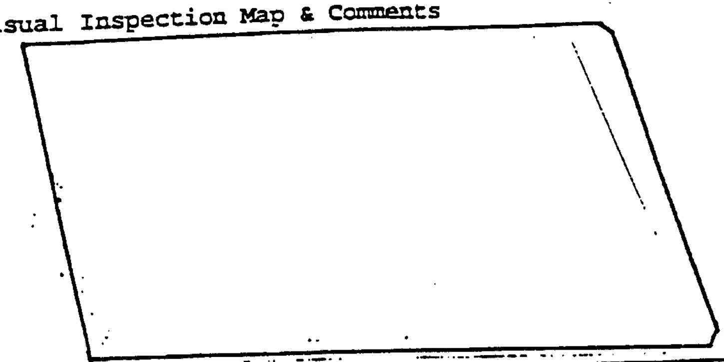
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) ______________________

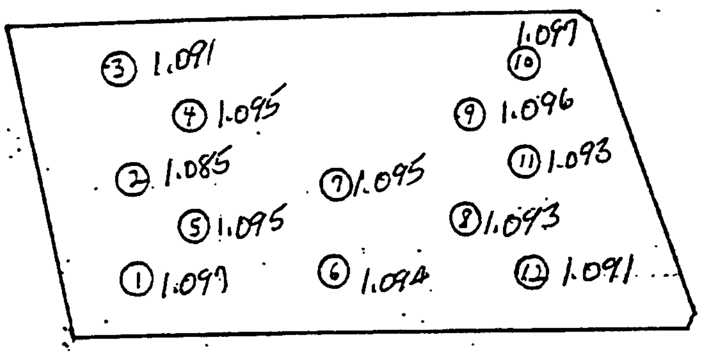
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks [illegible] 6-3-93

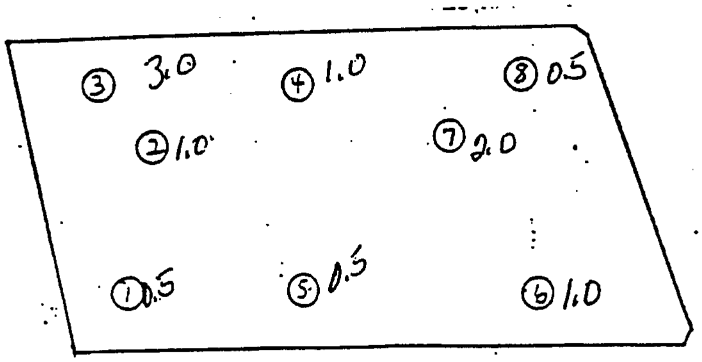
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-030

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	34.8 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	312	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	AMok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	AMok		
	S.E. to S.E.:	AMok		
Nesa Scratch Test (350 VAC):		AMok	MAY 25 1993	22 PPG 77
Light Transmittance:		77.3	MAY 25 1993	22 PPG 77
Haze:		1.3	MAY 25 1993	22 PPG 77
Photo (Single Exposure):				
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 3.0 3: 2.0 4: 1.0
5: 0.5 6: 0.5 7: 1.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:		MAY 25 1993	22 PPG 4
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.093 2: 1.095 3: 1.095 4: 1.008
5: 1.097 6: 1.095 7: 1.098 8: 1.098
9: 1.097 10: 1.097 11: 1.095 12: 1.095

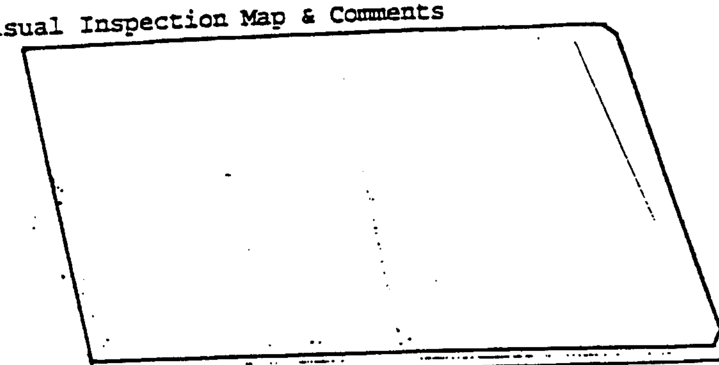
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) ______________________

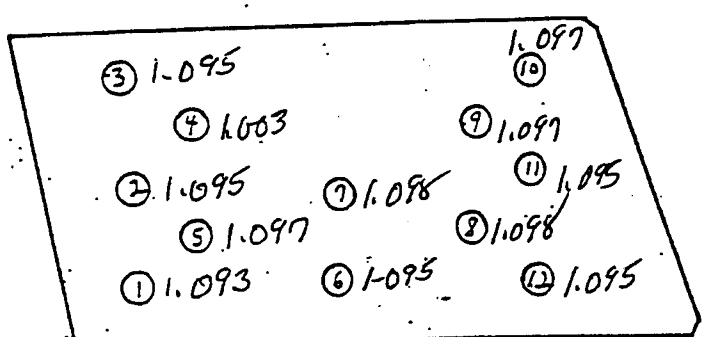
Visual Inspection: (Place comments on attached sheet) — Acc — JUN 02 1993 — 22 PPG 77

Check for vinyl cracks   Acc   6-3-83   22 PPB 77

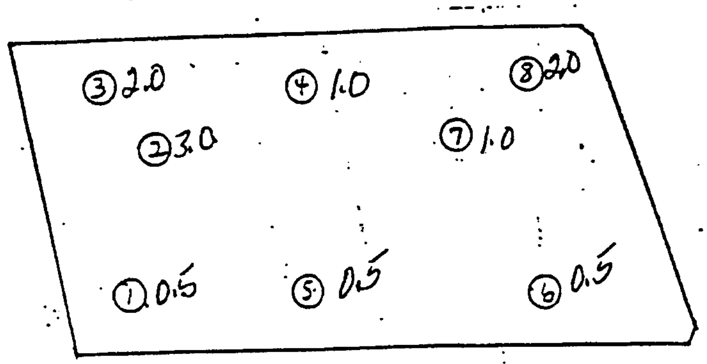
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-022

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	33.6 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	314	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	OK	MAY 25 1993	22 PPG 77
	S.E. to Metal:	OK		
	S.E. to S.E.:	OK		
Nesa Scratch Test (350 VAC):		OK	MAY 25 1993	22 PPG 77
Light Transmittance:		78.6	MAY 25 1993	22 PPG 77
Haze:		1.3	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.15 2: 0.0 3: 1.0 4: 0.0
5: 0.5 6: 1.0 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.000 2: 1.097 3: 1.095 4: 1.090
5: 1.098 6: 1.004 7: 1.105 8: 1.103
9: 1.105 10: 1.102 11: 1.098 12: 1.100

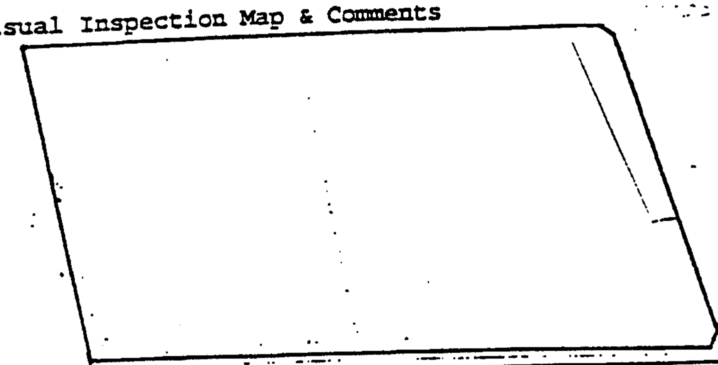
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) ______

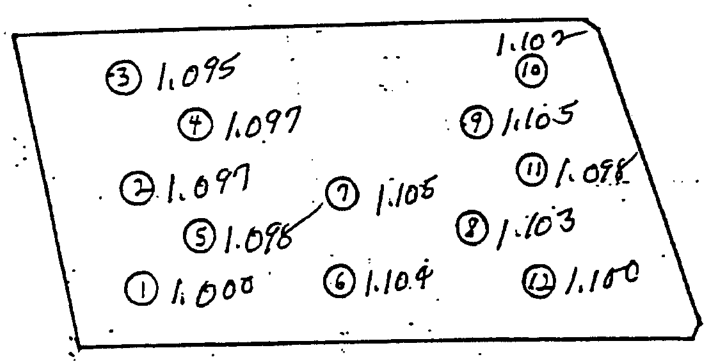
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks Abc 6-3-93 22 PPG

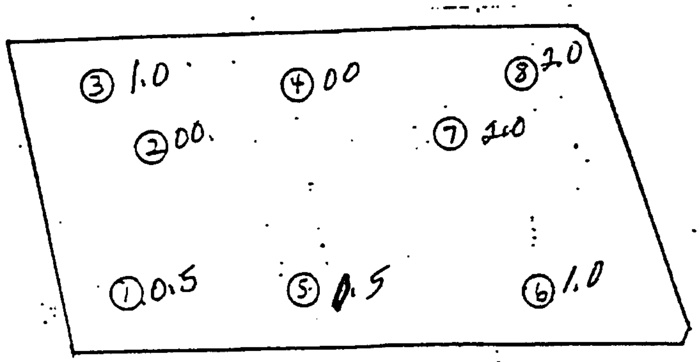
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-096

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	33.5 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	308	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc OK	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc OK		
	S.E. to S.E.:	Acc OK		
Nesa Scratch Test (350 VAC):		Acc OK	MAY 25 1993	22 PPG 77
Light Transmittance:		77.8	MAY 25 1993	22 PPG 77
Haze:		1.3	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 2? 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc 5-25-93	5-25-93	22 PPG 22

1: 2.0	2: 2.0	3: 2.0	4: 2.0
5: 0.5	6: 1.0	7: 2.0	8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc 5-25-93	5-25-93	22 PPG 28

1: 1.098	2: 1.100	3: 1.105	4: 1.105
5: 1.099	6: 1.103	7: 1.105	8: 1.105
9: 1.108	10: 1.105	11: 1.100	12: 1.103

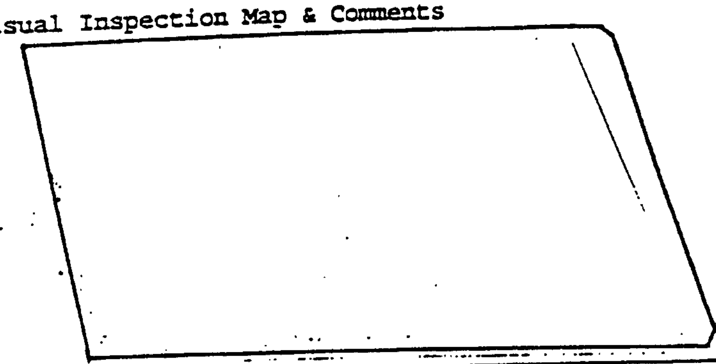
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments)

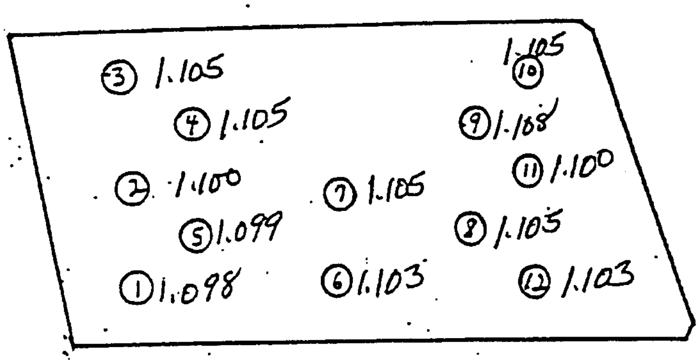
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks Aac 6-3-83 22 APR 77

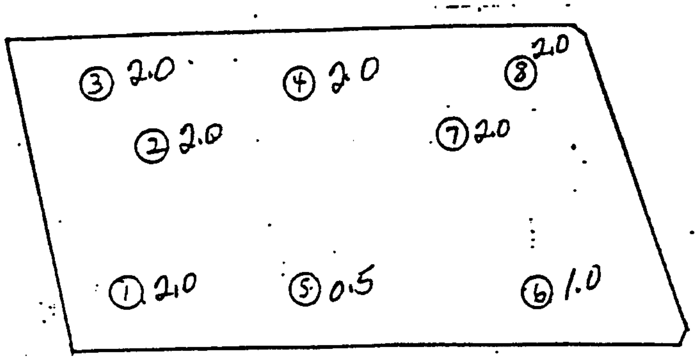
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-9-19-282

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.7 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-19-93	22 PPG 28
S.E. Resistance:	314	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc		
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc		
Light Transmittance:		82.3		
Haze:		1.1		
Photo (Single Exposure):			MAY 2 6 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc.	5-24-93	22 PPG 28

1: 3.0 2: 3.0 3: 3.0 4: 1.0
5: 1.0 6: 1.0 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-24-93	22 PPG 28

1: 1.094 2: 1.095 3: 1.096 4: 1.100
5: 1.002 6: 1.202 7: 1.105 8: 1.100
9: 1.201 10: 1.097 11: 1.100 12: 1.097

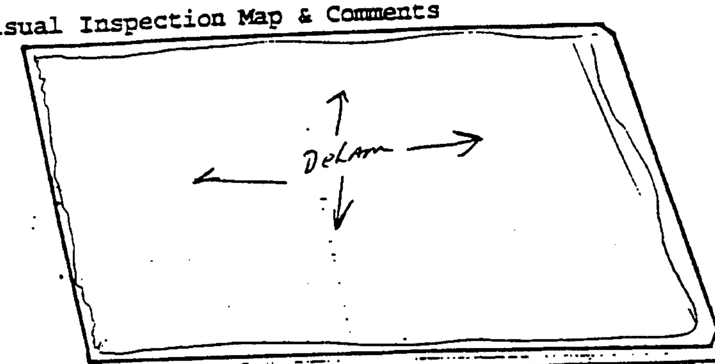
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 02 1993	PPG 77

(Comments) Wrong seal on outbd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 02 1993	22 PPG 77

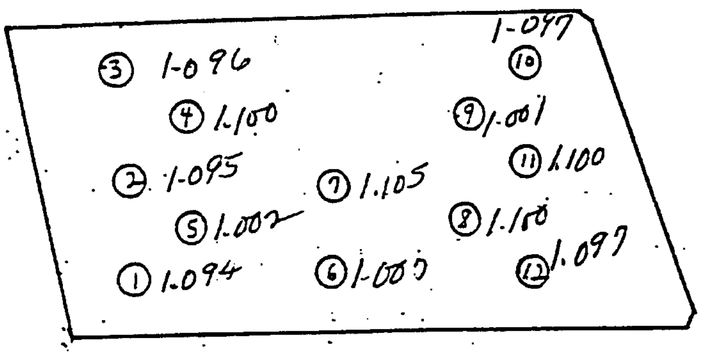
Check for vinyl cracks Ade 6-3-93 [redacted] PPG 77

Visual Inspection Map & Comments

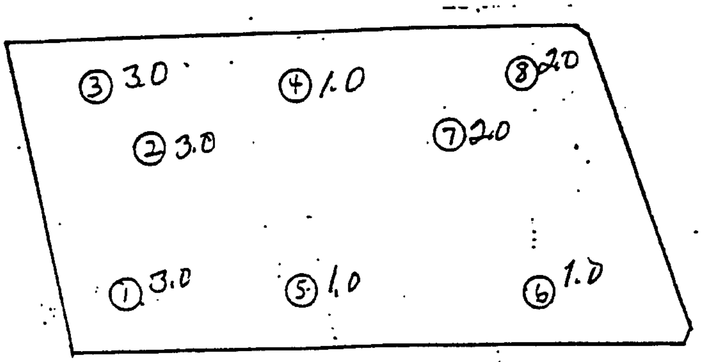


DeLAm Located All Around the Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-8-15-756

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	46.0 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-19-93	22 PPG 28
S.E. Resistance:	.313	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc	MAY 25 1993	22 PPG 77
Light Transmittance:		80.7	MAY 25 1993	22 PPG 77
Haze:		1.0	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-24-93	22 PPG 28

1: 2.0 2: 0.5 3: 1.0 4: 1.0
5: 0.5 6: 0.5 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-24-93	22 PPG 28

1: 1.077 2: 1.082 3: 1.084 4: 1.085
5: 1.085 6: 1.085 7: 1.087 8: 1.085
9: 1.087 10: 1.086 11: 1.085 12: 1.085

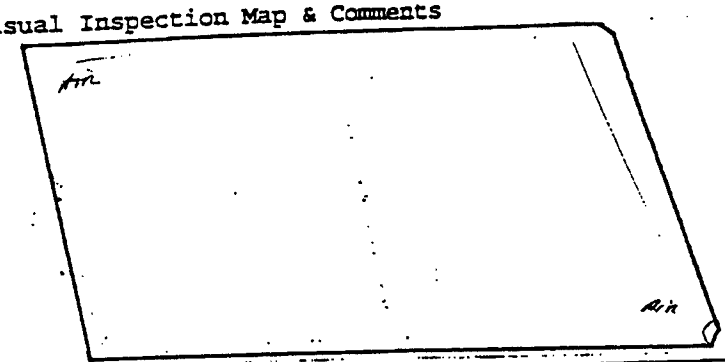
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments) WRONG SEAL ON OUTBd. Side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 79

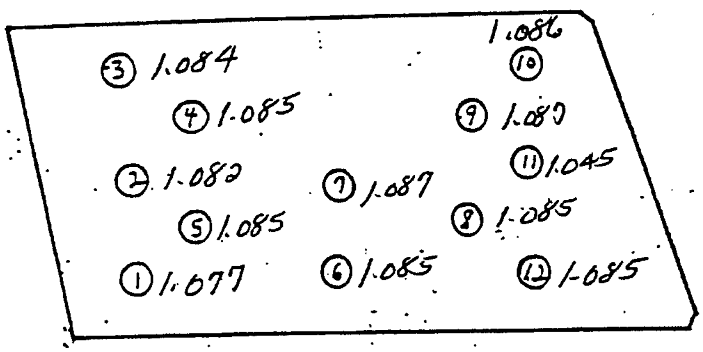
Check for vinyl cracks   Ace   6-3-93   22 PP6 77

Visual Inspection Map & Comments

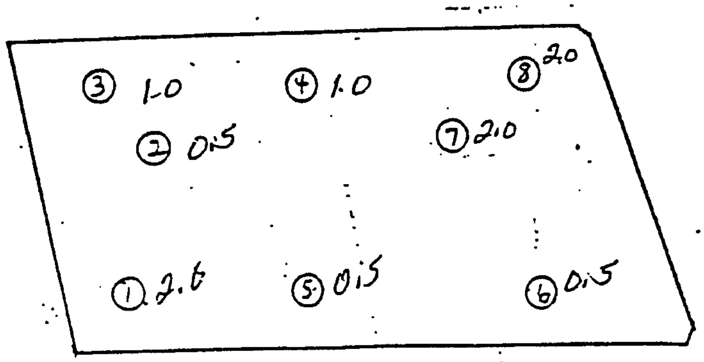


Air starting along edge of unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 84-H-3-19-220

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	44.5 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	314	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	146 Ms.E. to S.E.:			
Nesa Scratch Test (350 VAC):	Unit center 46.1	A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.3	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 1.0 2: 2.0 3: 2.0 4: 0.5
5: 0.5 6: 2.0 7: 1.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.093 2: 1.090 3: 1.089 4: 1.094
5: 1.094 6: 1.092 7: 1.096 8: 1.091
9: 1.092 10: 1.091 11: 1.091 12: 1.093

	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) Seal Needs cutting

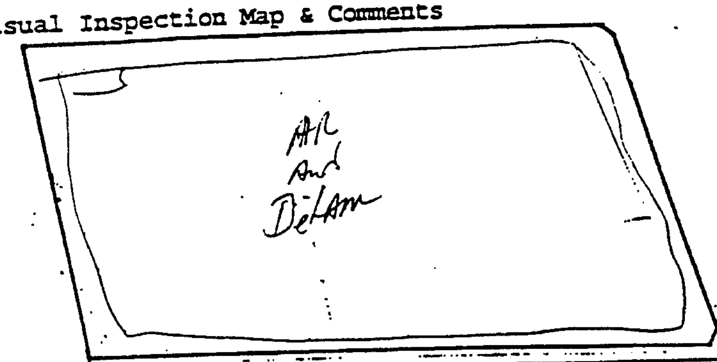
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

Check for vinyl cracks

JUN 04 1993

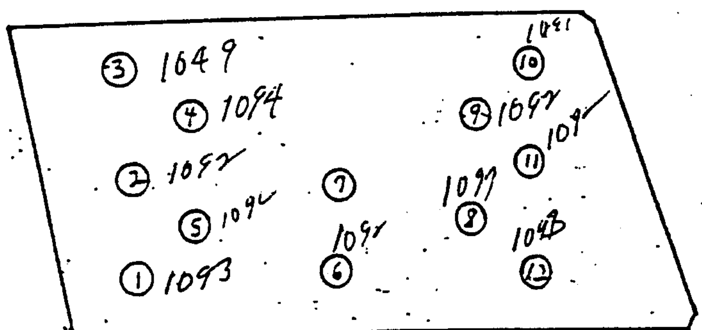
22 PPG 77

Visual Inspection Map & Comments

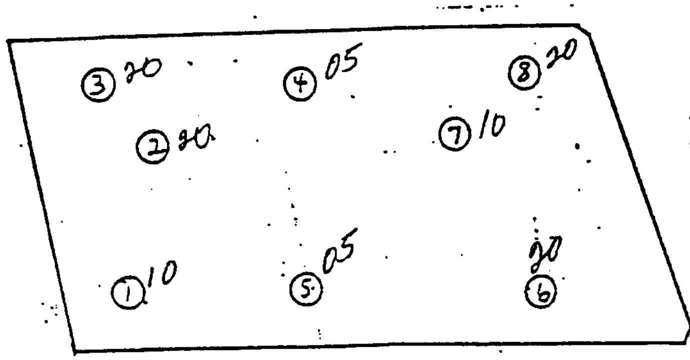


UNIT HAS AIR / Delam LOCATED THROU OUT.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-84354-501

Unit Serial Number: 86-H-12-01-146

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	36.5 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-21-93	22 PPG 28
S.E. Resistance:	309	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc	MAY 25 1993	22 PPG 77
Light Transmittance:		81.0	MAY 25 1993	22 PPG 77
Haze:		.8	MAY 25 1993	22 PPG 28
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5.24-93	22 PPG 28

1: 3.0 2: 3.0 3: 2.0 4: 4.0
5: 2.0 6: 0.5 7: 4.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:		~~MAY 26 1993~~	~~22 PPG 4~~ VOID 5-26-93 Acc
Unit Thickness: (Per Template)	Acc	5-24-93	22 PPG 28

1: 1.093 2: 1.094 3: 1.095 4: 1.098
5: 1.094 6: 1.101 7: 1.102 8: 1.100
9: 1.098 10: 1.099 11: 1.103 12: 1.101

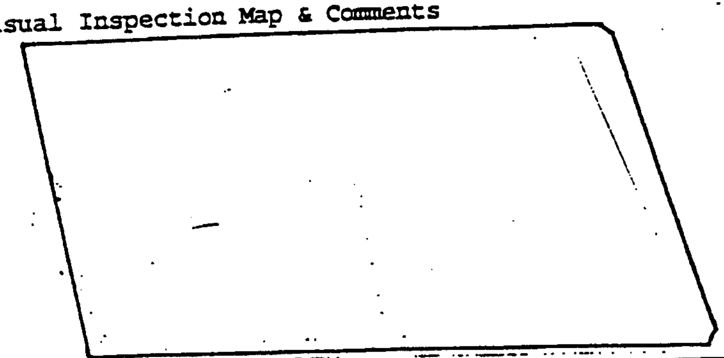
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments) Wrong Seal on outbd

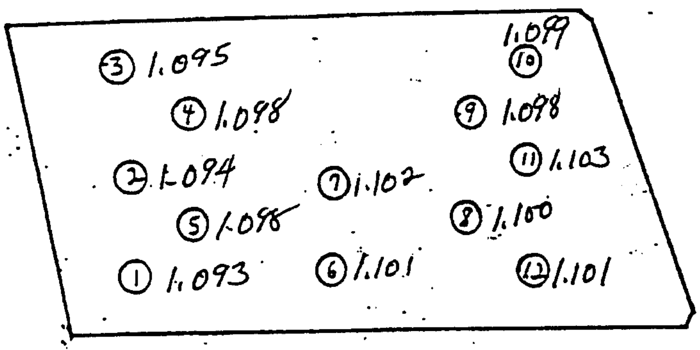
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks Ace 6-393 PPG 77

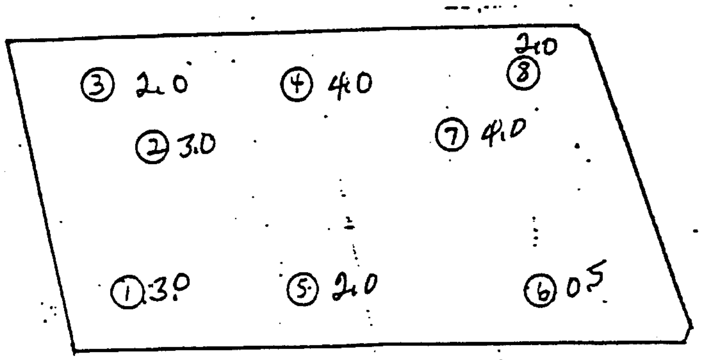
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-10-18-107

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.3 Ohms	--	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.311	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	40.8 DIST FWD Center & Lower	A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.8	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG R
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 3.0 2: 3.0 3: 2.0 4: 0.5
5: 2.0 6: 1.0 7: 2.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.093 2: 1.089 3: 1.093 4: 1.094
5: 1.095 6: 1.096 7: 1.096 8: 1.096
9: 1.095 10: 1.091 11: 1.090 12: 1.092

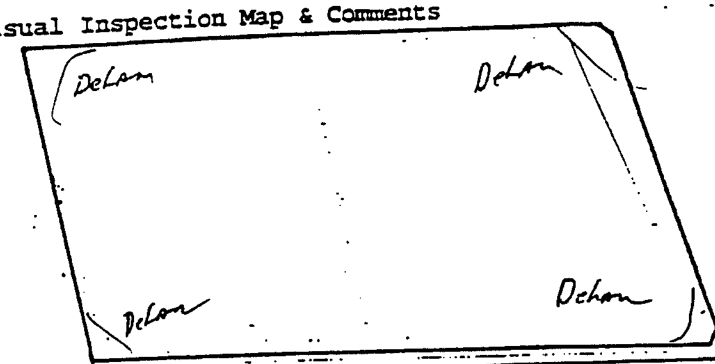
	Acc/Rej	Date	Inspector
Seal Evaluation:	Res	JUN 04 1993	22 PPG 77

(Comments) Seal Needs Cutting to size

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 04 1993	22 PPG 77

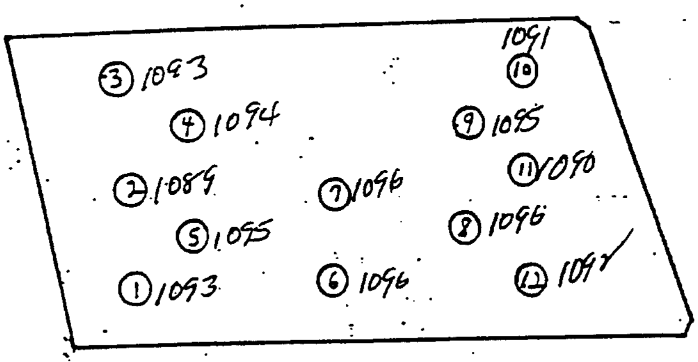
Check for vinyl cracks JUN 04 1993

Visual Inspection Map & Comments

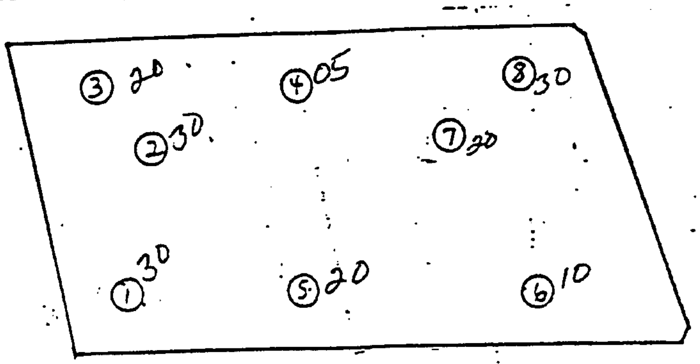


DeLam Located in All Four Corner

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-9-6-235

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	43.4 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.311	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC) TOP FWD	Power to S.E.:	Acc		
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
5/5 AIR ATTITUDE S/E Res High 447 Nesa Scratch Test (350 VAC):		A	JUN 09 1993	22 PPG 39
Light Transmittance:	74.8	A	JUN 09 1993	22 PPG 39
Haze:	13	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc 5-26-9	5-26-93	22 PPG 28

1: 2.0 2: 2.0 3: 2.0 4: 1.0
5: 0.5 6: 2.0 7: 2.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

1: 1.090 2: 1.093 3: 1.090 4: 1.091
5: 1.044 6: 1.097 ✓ 7: 1.097 8: 1.095
9: 1.095 10: 1.090 11: 1.091 12: 1.085

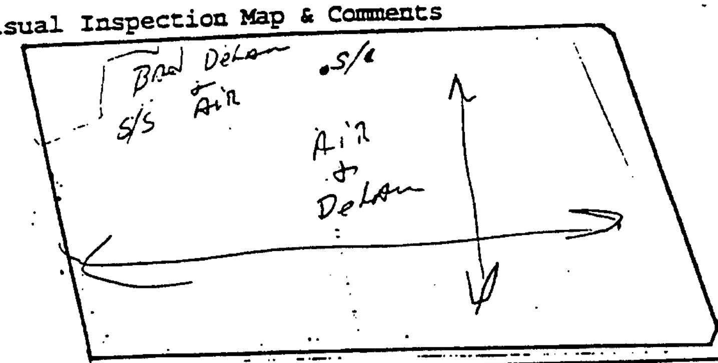
	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Res	JUN 04 1993	22 PPG 77

Seal Needs Cutting on Outbd Side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 04 1993	22 PPG 77

Check for vinyl cracks ACC JUN 04 1993 22 PP8

Visual Inspection Map & Comments

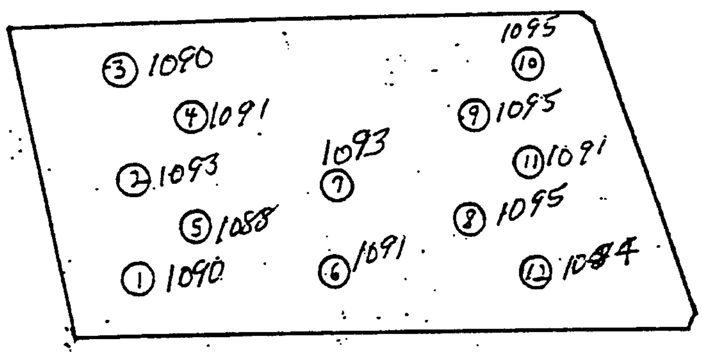


Air And DeLam LOCATed ALL Around Unit

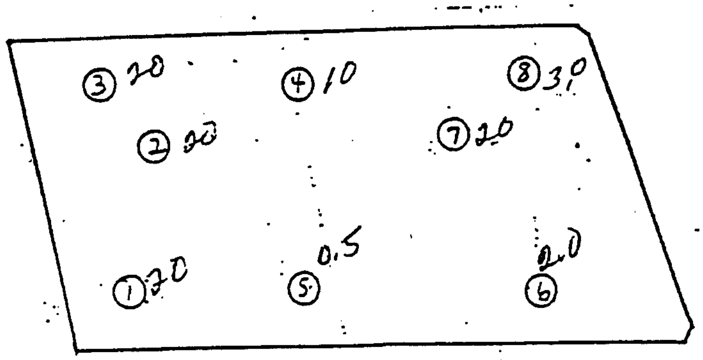
SURface SCR LOCATed As marked

SURface chip LOCATed AS MARKed

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-11-21-325

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	45.7 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.313	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	17.0 Res High	A	JUN 09 1993	22 PPG 39
Light Transmittance:	73.7	A	JUN 09 1993	22 PPG 39
Haze:	.8	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG
Deviation Inspection: (German Light per Template)		Acc	1-25-93	22 PPG 28

1: 1.0 2: 2.0 3: 1.0 4: 1.0
5: 1.0 6: 0.5 7: 2.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:	/		
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.090 2: 1.092 3: 1.083 4: 1.088
5: 1.090 6: 1.092 7: 1.090 8: 1.090
9: 1.088 10: 1.085 11: 1.089 12: 1.089

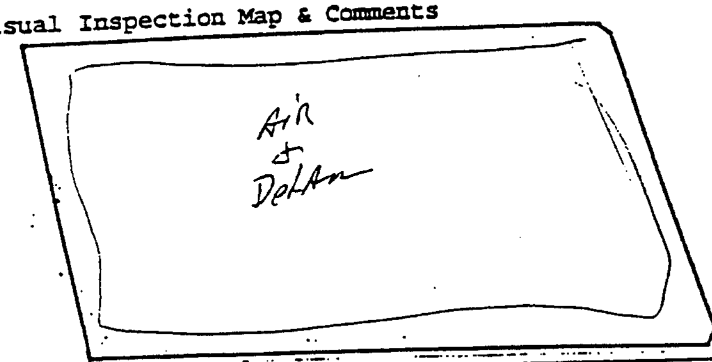
	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Rej	JUN 04 1993	22 PPG 77

Seal Need To Be Trimed. Backi

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

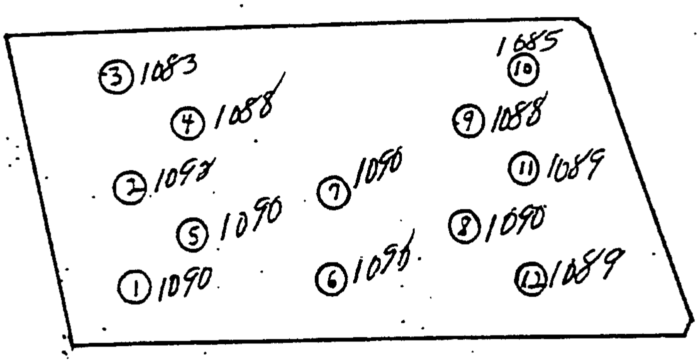
Check for vinyl cracks Aca JUN 04 1993 22 PP6.77

Visual Inspection Map & Comments

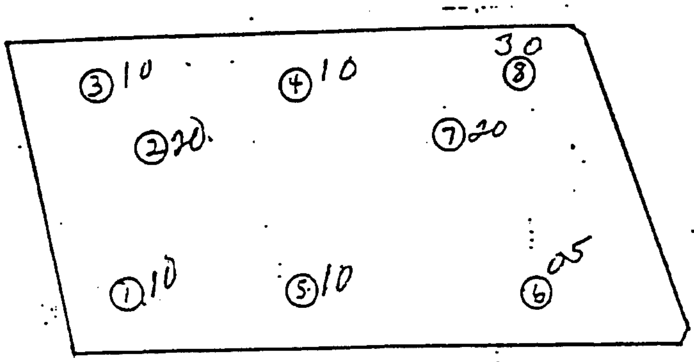


AIR And DeLAm LOCATed Around The Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 89 286 ~~HO~~ H.O 697

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	38.0 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.309	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
37.7 DIST E/E Nesa Scratch Test (350 VAC):		A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.9	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 2.0 2: 3.0 3: 2.0 4: 3.0
5: 2.0 6: 0.5 7: 3.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.080 2: 1.080 3: 1.085 4: 1.085
5: 1.080 6: 1.086 7: 1.083 8: 1.089
9: 1.089 10: 1.090 11: 1.086 12: 1.087

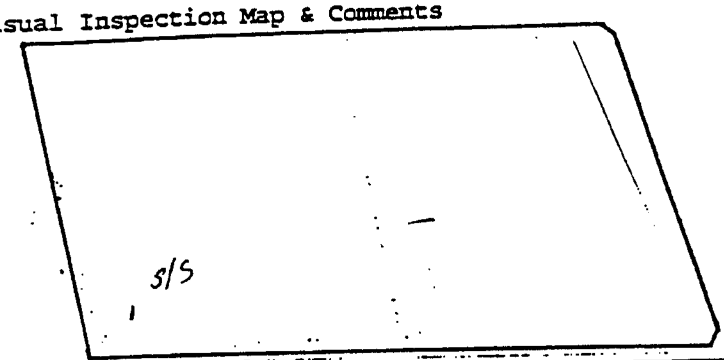
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) Seal Needs cutting on OUTBd Side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

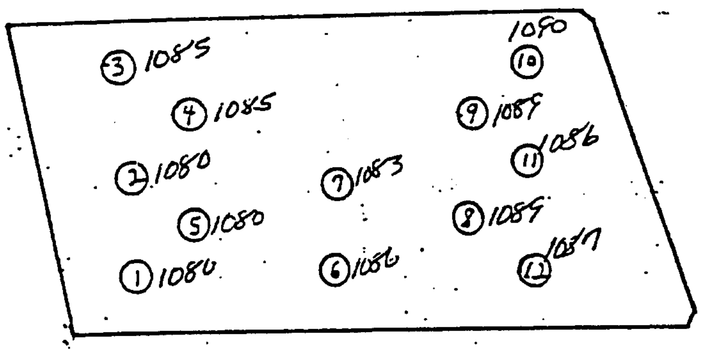
Check for vinyl cracks Ado JUN 04 1993 22 PPG 77

Visual Inspection Map & Comments

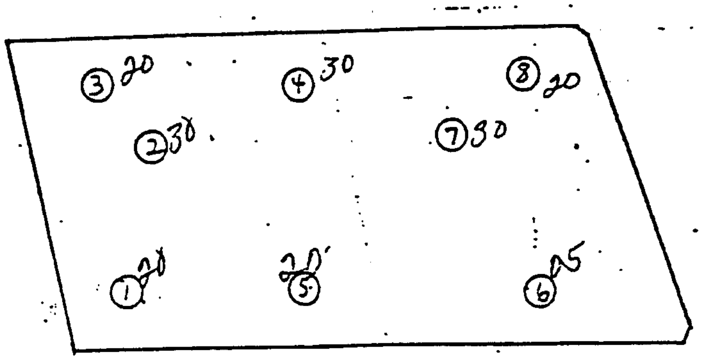


SURface ScR Located As MARKed

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

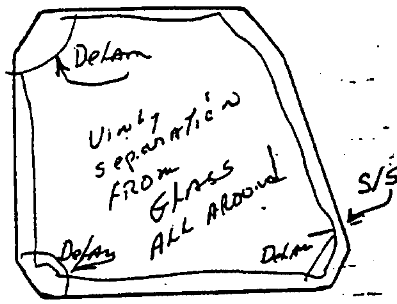
Customer Part Number: 5-89357-1
Unit Serial Number: B75-1149

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 71.1 Ohms	A	5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test Power to Metal: (2500 VAC)	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.8	MAY 2 6 1993	22PPG43
Haze:	1.8	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <10 2: <10 3: <10 4: <10	Ac	JUN 0 9 1993	22 PPG 39
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .740 2: .741 3: .757 4: .740	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	PPG 77

(Comments) Wrong Seal on outbd.

Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

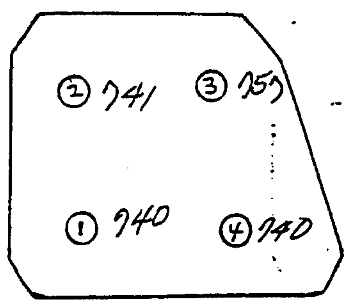
Visual Inspection Map & Comments



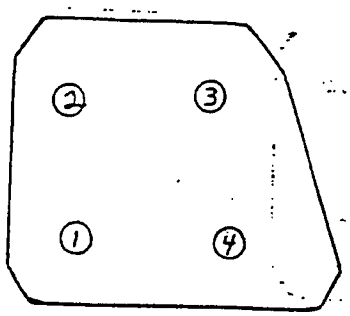
Vinly Separation from Glass edge All Around
unit inBd side.

DeLam Around unit in corner unit has
surface sep. remover Between ply.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

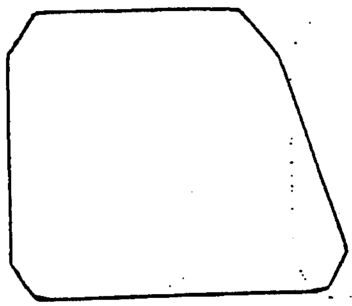
Unit Serial Number: 92 064 HO 471

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	69.8 Ohms	Acc	5-24-93	22 PPG 77
Thermal Image:			5-24-93	22 PPG 77
Insulation Test: (2500 VAC)	Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):		Acc	MAY 26 1993	22 PPG 77
Light Transmittance:		79.7	MAY 26 1993	22 PPG 77
Haze:		1.5	MAY 26 1993	22 PPG 77
Photo (Single Exposure):			26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 3		Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:				
Unit Thickness: (Per Template) 1: .698 2: .690 3: ~~.797~~ .697 4: .692		Acc	5-25-93	22 PPG 77
Check for Vinyl Cracks:		Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:		Acc	JUN 02 1993	22 PPG 77

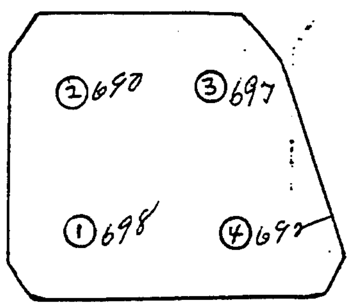
(Comments) ______________________________

Visual Inspection: (Place comments on attached sheet) Acc JUN 02 1993 22 PPG 77

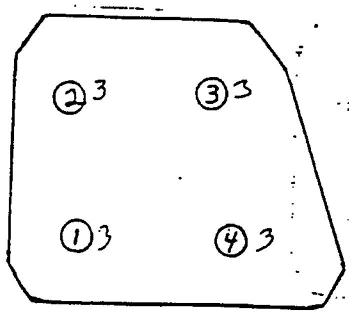
Visual Inspection Map & Comments



Thickness Template



Deviation Template



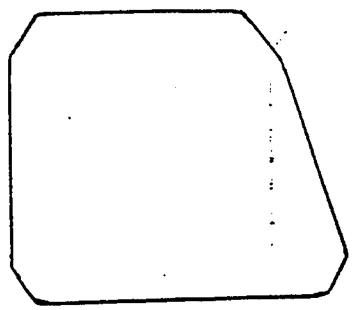
KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

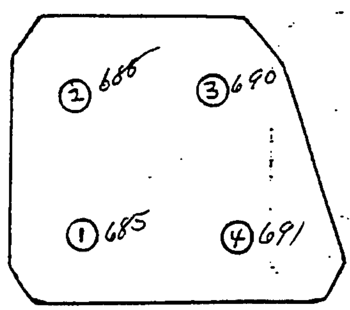
Unit Serial Number: 92-064-H0-473

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	39.4 Ohms	Acc	5-24-93	22 PPG 22
Thermal Image:			5-24-93	22 PPG 22
Insulation Test: (2500 VAC)	Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):		Acc	MAY 26 1993	22 PPG 77
Light Transmittance:		79.9	MAY 26 1993	22 PPG 77
Haze:		1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):			26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: .3 2: 3 3: 3 4: 3		Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:				
Unit Thickness: (Per Template) 1: .685 2: .688 3: .690 4: .691		Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:		Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:		Acc	JUN 02 1993	22 PPG 77
(Comments)				
Visual Inspection: (Place comments on attached sheet)		Acc	JUN 02 1993	22 PPG 77

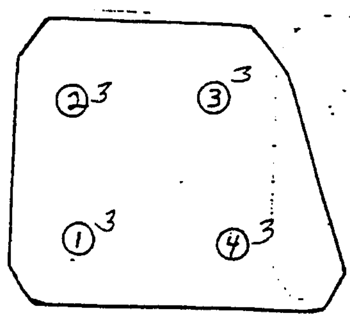
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

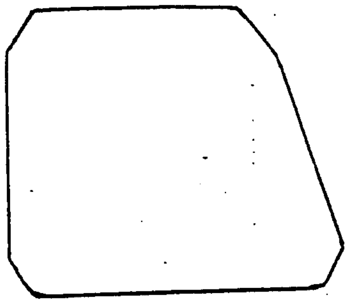
Unit Serial Number: 92 059 HO 350

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 70.1 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	79.7	MAY 26 1993	22 PPG 77
Haze:	1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 3	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .689 2: .690 3: .691 4: .682	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

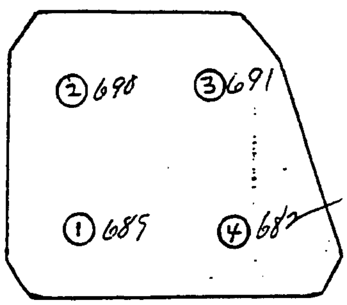
(Comments)

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

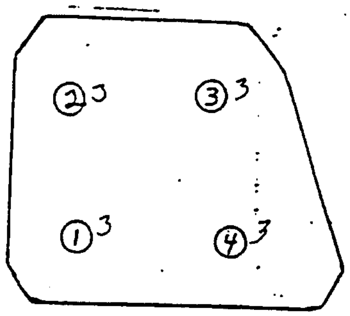
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

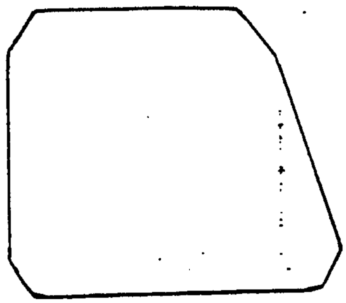
Unit Serial Number: 92-025-#0-006

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 69.3 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.2	MAY 26 1993	22 PPG 77
Haze:	1.1	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 5 2: 3 3: 3 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .694 2: .693 3: .695 4: .690	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

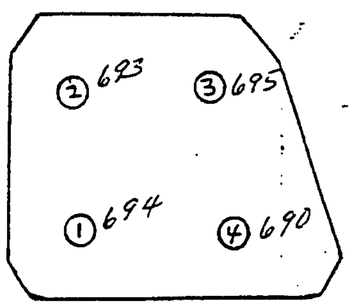
(Comments) ______________________

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

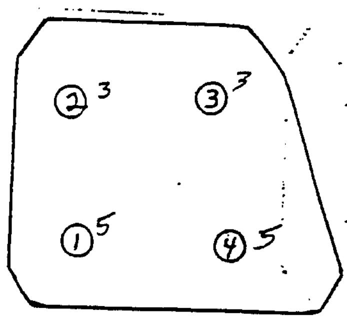
Visual Inspection Map & Comments



Thickness Template



Deviation Template



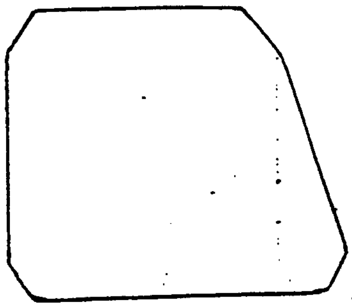
KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

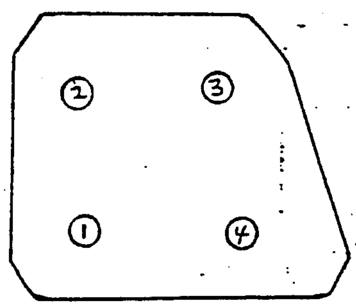
Unit Serial Number: 92-119 H0 186

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	64.8 Ohms	Acc	9/2/93	22 PPG 15
Thermal Image:			9/2/93	
Insulation Test: (2500 VAC)	Power to Metal:	Acc	9/2/93	22 PPG 15
Nesa Scratch Test (81 VAC):		Acc	9/2/93	22 PPG 15
Light Transmittance:	81.5	Acc	9/2/93	22 PPG 15
Haze:	.9	Acc	9/2/93	22 PPG 15
Photo (Single Exposure):				
Deviation Inspection: (German Light per Template) 1: 5 2: 5 3: 3 4: 5		Acc	9/2/93	22 PPG 15
Dimensional Inspection:				
Unit Thickness: (Per Template) 1: .686 2: .686 3: .688 4: .688		Acc	9/2/93	22 PPG 15
Check for Vinyl Cracks:		Acc	9/2/93	22 PPG 15
Seal Evaluation:		Acc	9/2/93	22 PPG 15
(Comments)				
Visual Inspection: (Place comments on attached sheet)		Acc	9/2/93	22 PPG 15

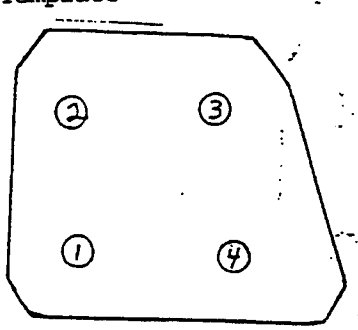
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

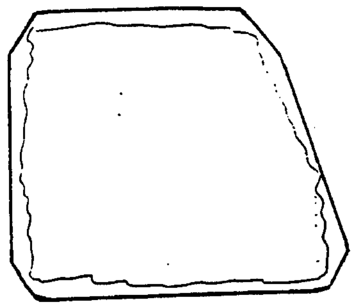
Unit Serial Number: 85-H-07-01-276

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	______ Ohms	* ReJ	MAY 26 1993	22 PPG 77
Thermal Image:				
Insulation Test: (2500 VAC)	Power to Metal:			
Nesa Scratch Test (81 VAC):		* ReJ	MAY 26 1993	22 PPG 77
Light Transmittance:		82.9	MAY 26 1993	22 PPG 77
Haze:		1.0	MAY 26 1993	22 PPG 77
Photo (Single Exposure):			26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 4 2: 10 3: 7 4: 4		Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:				
Unit Thickness: (Per Template) 1: ~~.74~~ .693 E.L. 2: .700 3: .695 4: .692				
Check for Vinyl Cracks:		Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:		ReJ	JUN 02 1993	22 PPG 77

(Comments) * Open circuit
wrong seal on outbd side
inside sealant

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	ReJ	JUN 02 1993	22 PPG 77

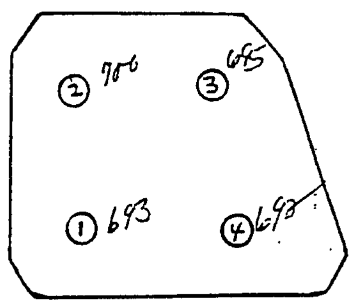
Visual Inspection Map & Comments



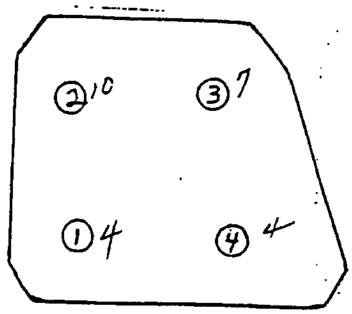
open Power Circuit

UNIT HAS AIR ALL ROOND THE UNIT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

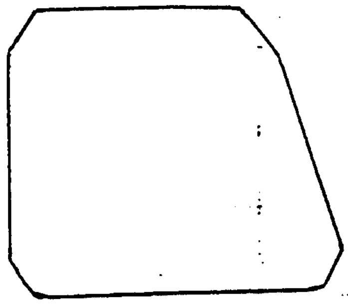
Unit Serial Number: 90 173 HO 721

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 68.4 ohms	Rej ~~Accept~~ 6-2-93	MAY 26 1993	22 PPG 77
Thermal Image:			
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.9	MAY 26 1993	22 PPG 77
Haze:	1.0	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template) 1: 7 2: 7 3: 3 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .686 2: .682 3: .688 4: .684	Acc.	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments) Wrong type of seal on outbd side ~~Bad Joint~~ open circuits sometime a reading and other times no reading

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

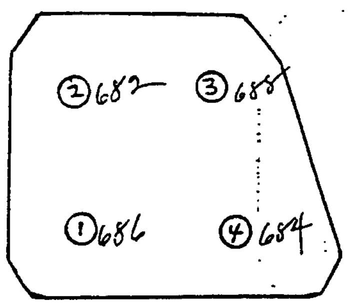
Visual Inspection Map & Comments



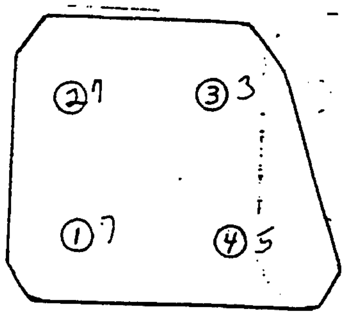
Open Power Circuit

wrong Type of Seal on outBd side

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-13 Chg F

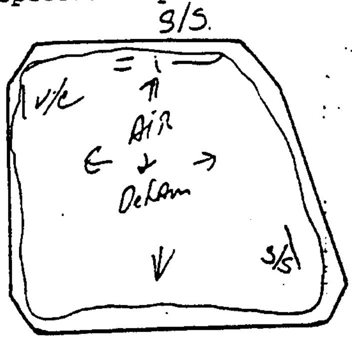
Unit Serial Number: 5-H-5-23-84

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 118.0 ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	80.7	MAY 2 6 1993	22PPG43
Haze:	.4	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: < 3 2: < 3 3: < 3 4: < 3	Acc	6-8-93	22 PPG 18
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .642 2: .643 3: .684 4: .686	Acc.	5-21-93	22 PPG 28
Check for Vinyl Cracks:	Rej.	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) BAd Seal + Bumper on outbd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

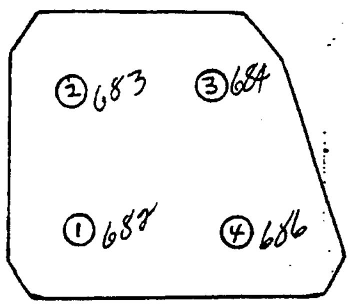


AiR & DeLam : LocaTed ALL ARound UniT

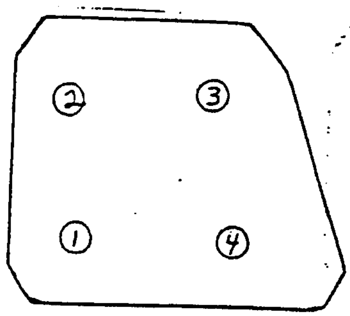
Vinly CRACK LocATed AS mARKed

SURFACe SCR LocaTed AS mARKed

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501 Chg. H.

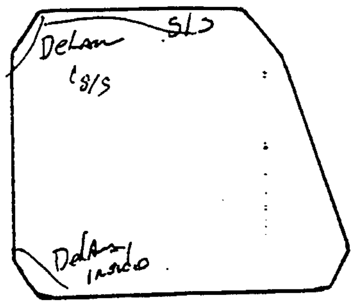
Unit Serial Number: 7-H-2-4-35

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 119.8 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc.	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	81.6	MAY 2 6 1993	22PPG43
Haze:	.9	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <3 2: <3 3: <3 4: <3	ok	6-8-93	22 PPG 10
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .696 2: .694 3: .692 4: .692	Acc.	5-26-93	22 PPG 28
Check for Vinyl Cracks:		JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) BAD Bumper

Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

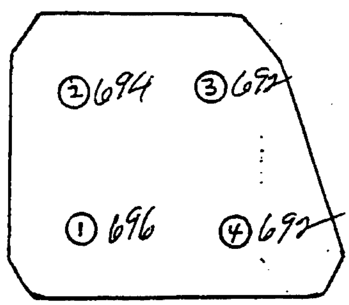
Visual Inspection Map & Comments



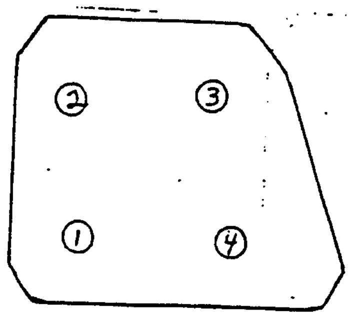
AIR And DeLAm Located ARound the end

Surface Scr. Located As marked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764

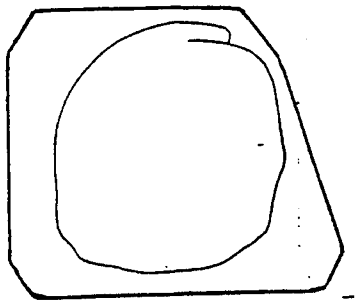
Unit Serial Number: 4-H-10-9-69

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 85.0 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc.	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.2	MAY 2 6 1993	22PPG43
Haze:	1.0	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: < 3 2: < 3 3: < 3 4: < 3	Ac	6-8-93	22 PPG 10
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .677 2: .678 3: .679 4: .676	Acc.	5-21-93	22 PPG 28
Check for Vinyl Cracks:	Rej	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) No Seal or Bumper

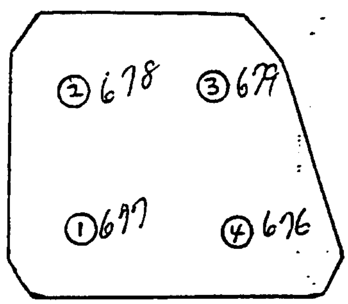
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

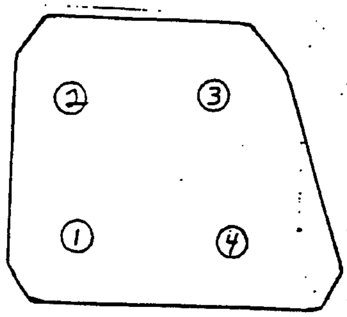


Air / Delam / Vinly Cracks Located All
Around Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

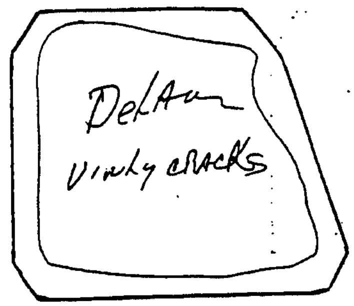
Unit Serial Number: 82-H-12-6-392

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 79.7 Ohms		5-21-93	82 [illegible]
Thermal Image:		5-21-93	82 [illegible]
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.3	MAY 2 6 1993	22PPG43
Haze:	1.0	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: 2.3 2: 2.4.5 3: 4.5 4: 2	Acc	6-8-93	22 PPG 10
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .666 2: .666 3: .668 4: .665	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Res	JUN 0 3 1993	22 PPS 77
Seal Evaluation:	Res	JUN 0 3 1993	22 PPS 77

(Comments) No seal or Bumper

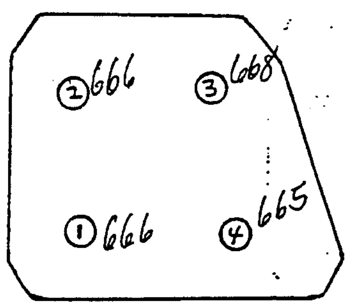
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 0 3 1993	22 PPS 77

Visual Inspection Map & Comments

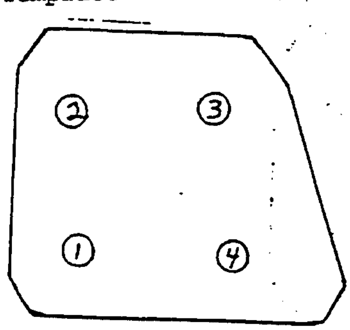


AIR, DeLam And Vinly cRAcKS LocAted ALL AROUND UNIT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

Unit Serial Number: 6-H-12-02-36

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 123.2 / 96.8 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.2	MAY 2 6 1993	22PPG43
Haze:	.8	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PFG 47	JUN 1 4 1993	22 PPG 28
Deviation Inspection: (German Light per Template)	A	JUN 0 9 1993	22 PPG 39

1: <3 2: <3 3: <3 4: <3

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

1: .687 2: .686 3: .684 4: .685

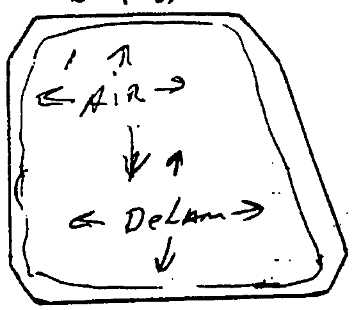
	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) NO Bumper on outbd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

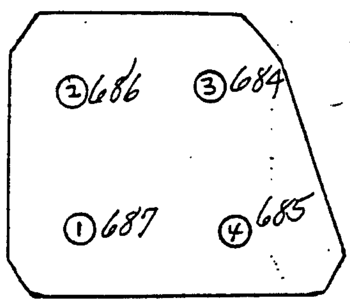
Deep S/S



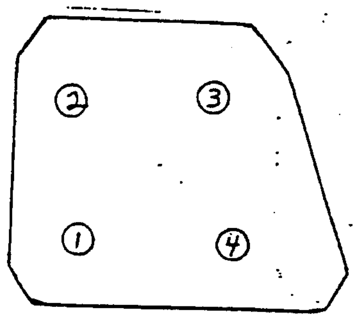
B/B Res. 123.2 ~~before~~ before T.I 96.8 after T.I

AIR ALL AROUND of UNIT And ALSO DeLam

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

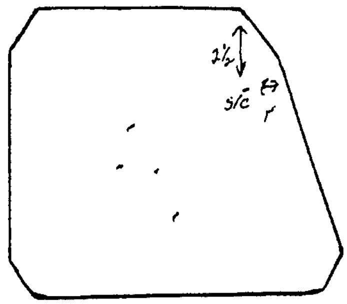
Unit Serial Number: 87-H-04-2D-130

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 73.1 Ohms	Acc.	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	86.5	MAY 26 1993	22 PPG 77
Haze:	1.5	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 9 2: 5 3: 7 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .695 2: .707 3: .712 4: .702	Acc.	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	RoJ	JUN 02 1993	22 PPG 77

(Comments) wrong seal on outbd side of unit

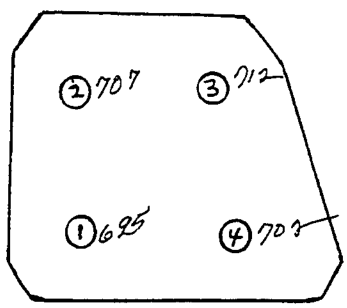
Visual Inspection: (Place comments on attached sheet)	ReJ	JUN 02 1993	22 PPG 77

Visual Inspection Map & Comments

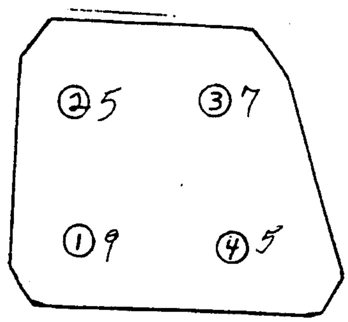


SURFACE CHIP LOCATED 2½" in down And 1" FROM fwd. edge
And OTHER SURFACE Defects LOCATED CENTER of UNIT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

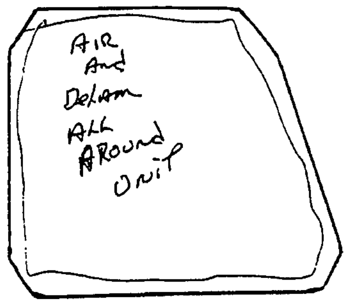
Customer Part Number: 5-71764-501 Chg-H

Unit Serial Number: 8-H-2-06-585

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 29.2 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.6	MAY 2 6 1993	22PPG43
Haze:	1.1	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <3 2: <3 3: <3 4: <3	Acc	6/8-93	22 PPG 40
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .692 2: .691 3: .693 4: .693			
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

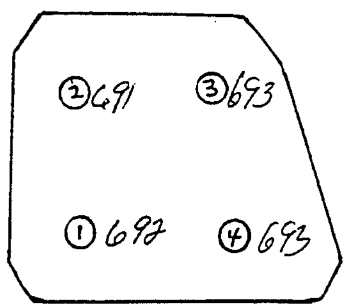
(Comments) Wrong seal on outbd side
Bumper is Bad on outbd side

Visual Inspection Map & Comments

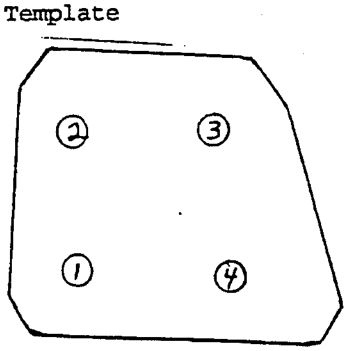


AiR And DeLAm LocATed ALL ARound UNiT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

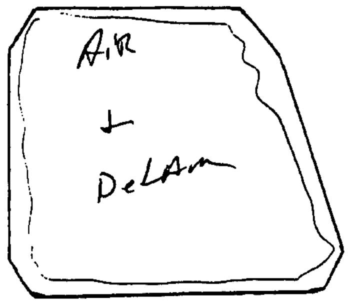
Unit Serial Number: 85-H-07-01-366

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 83.7 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	82.8	MAY 26 1993	22PPG43
Haze:	.8	MAY 26 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: < 3 2: < 4.5 3: < 7 4: < 4.5	Acc	6-8-93	[illegible]
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .699 2: .701 3: .697 4: .687	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 03 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 03 1993	22 PPG 77

(Comments) BAD Bumper and wrong Seal on outside side

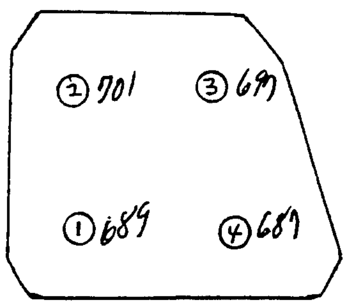
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 03 1993	22 PPG 77

Visual Inspection Map & Comments

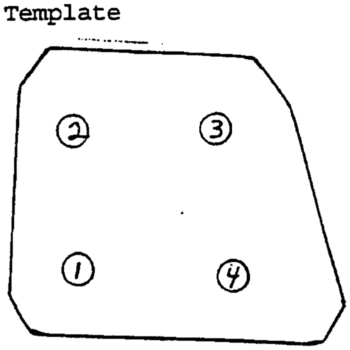


Air And Delam is Located All Around Unit.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

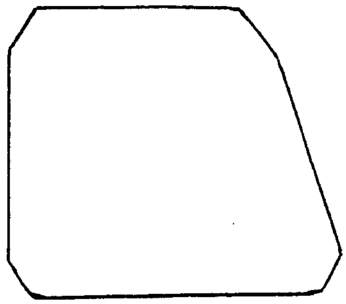
Unit Serial Number: 92 064 H0 470

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 74.4 Ohms	Acc.	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	78.6	MAY 26 1993	22 PPG 77
Haze:	1.3	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 3	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .683 2: .687 3: .686 4: .685	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

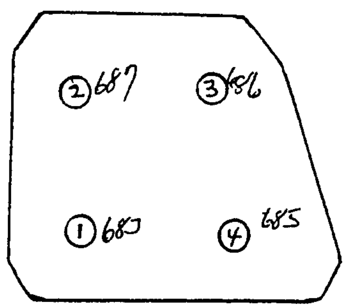
(Comments) ______________________

Visual Inspection: (Place comments on attached sheet) — Acc — JUN 02 1993 — 22 PPG 77

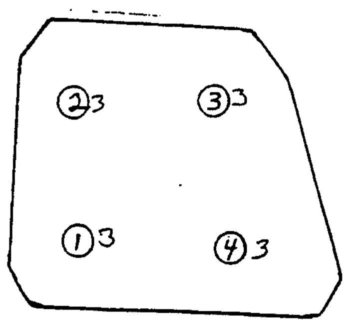
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

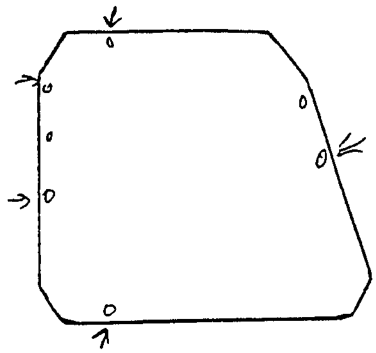
Unit Serial Number: 92-098 H0 591

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 67.D Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	78.9	MAY 26 1993	22 PPG 77
Haze:	1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 5 2: 5 3: 3 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .692 2: .683 3: .688 4: .690	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) Seal Loose But Acceptable

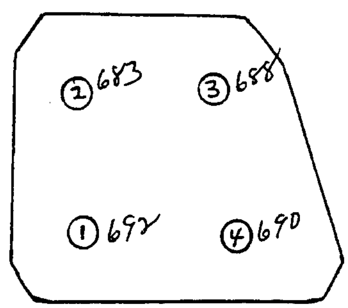
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Visual Inspection Map & Comments

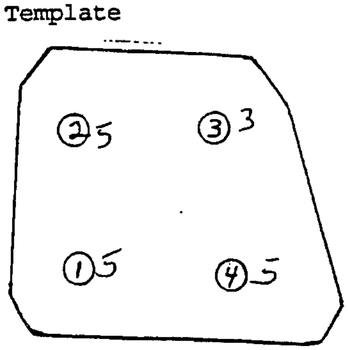


Seal Loose As Marked

Thickness Template



Deviation Template



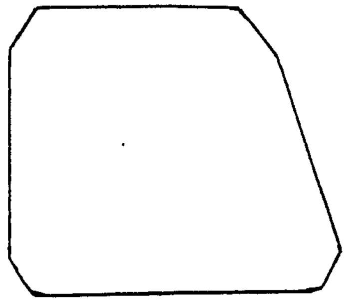
KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

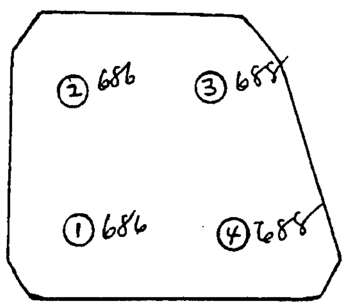
Unit Serial Number: 92-093 Ho 392

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	68.0 Ohms	Acc.	5-24-93	22 FPG 28
Thermal Image:			5-24-93	22 FPG 28
Insulation Test: (2500 VAC)	Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):		Acc	MAY 26 1993	22 PPG 77
Light Transmittance:		79.8	MAY 26 1993	22 PPG 77
Haze:		1.0	MAY 26 1993	22 PPG 77
Photo (Single Exposure):			26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template)	1: 5 2: 5 3: 3 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:				
Unit Thickness: (Per Template)	1: .686 2: .686 3: .688 4: .688	Acc	7-25-93	22 PPG 28
Check for Vinyl Cracks:		Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:		Acc	JUN 02 1993	22 PPG 77
(Comments)				
Visual Inspection: (Place comments on attached sheet)		Acc	JUN 02 1993	22 PPG 77

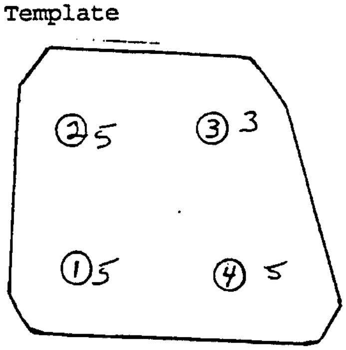
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

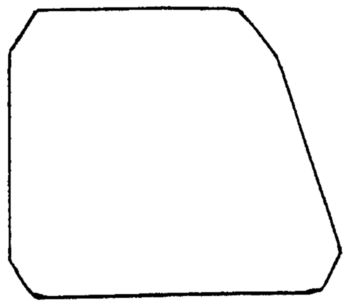
Unit Serial Number: 92-093-HO-388

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 73.7 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.6	MAY 26 1993	22 PPG 77
Haze:	1.5	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 77
Deviation Inspection: (German Light per Template) 1: 5 2: 5 3: 5 4: 7	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .688 2: .685 3: .691 4: .691	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	PPG 77

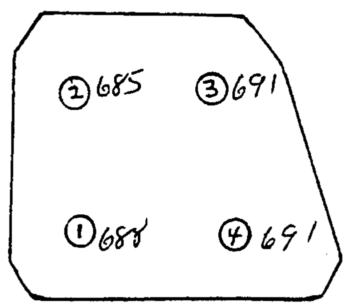
(Comments)

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

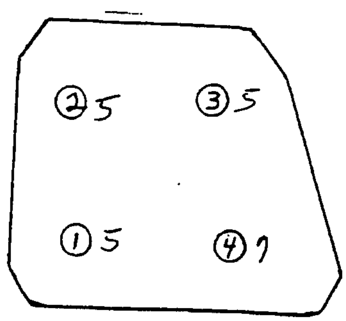
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501 Chg. H

Unit Serial Number: 5-H-12-16-47

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 101.0 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	81.2	MAY 26 1993	22PPG43
Haze:	1.5	MAY 26 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)	A	JUN 09 1993	22 PPG 39

1: ~~.644~~ <3 2: <3 3: <3 4: <3

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

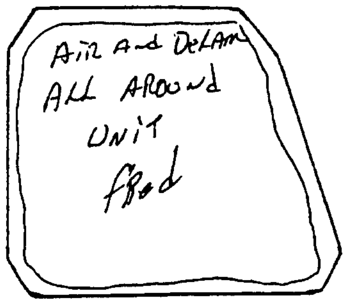
1: .684 2: .679 3: .685 4: .679

	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	Acc	JUN 03 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 03 1993	22 PPG 77

(Comments) WRONG SEAL ON OUTBD SIDE

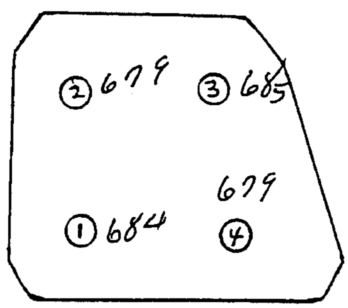
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 03 1993	22 PPG 77

Visual Inspection Map & Comments

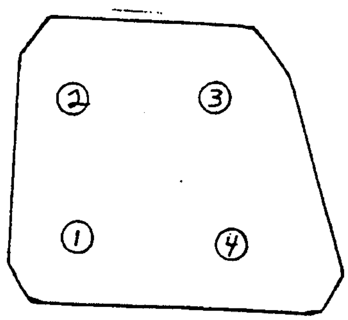


Air And Delam ALL Around Edge of Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

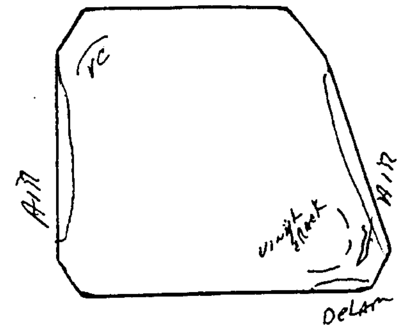
Unit Serial Number: 84-H-10-15-1225

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 79.3 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.8	MAY 26 1993	22 PPG 77
Haze:	1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .702 2: .704 3: .709 4: .700	Acc 5-25-93	5-25-93	22 PPG 28
Check for Vinyl Cracks:	RеJ	JUN 02 1993	22 PPG 77
Seal Evaluation:	ReJ	JUN 02 1993	22 PPG 77

(Comments) Wrong seal on outbd side and inside sealant very bad shape

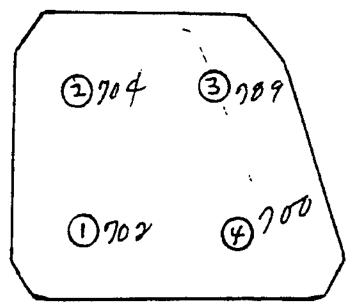
Visual Inspection: (Place comments on attached sheet)	RеJ	JUN 02 1993	22 PPG 77

Visual Inspection Map & Comments

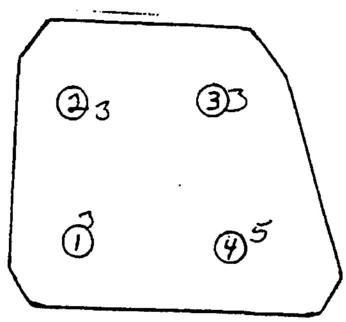


AIR Located ALL ROUND UNIT. PLUS A LARGE
Amount Located LOWER/FWD. Along with delam
Also Vinly cRacks believe To Be STARTing

Thickness Template



Deviation Template



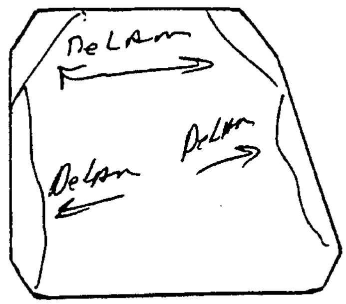
KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-57164-13 Chg-F

Unit Serial Number: 4-H-9-28-87

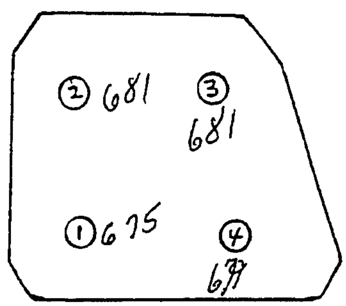
	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 85.6 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	87.1	MAY 26 1993	22PPG43
Haze:	1.2	MAY 26 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <3 2: <3 3: <3 4: <3	A	JUN 09 1993	22 PPG 39
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .675 2: .681 3: .681 4: .679	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 03 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 03 1993	22 PPG 77
(Comments)			
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 03 1993	22 PPG [illegible]

Visual Inspection Map & Comments

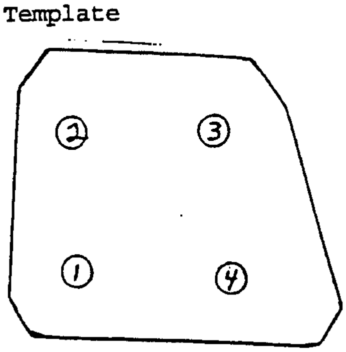


DeLAm And Air ALL ARound unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-89357-1

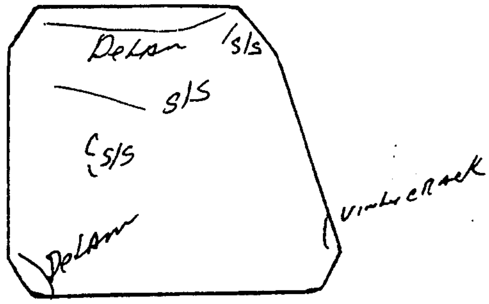
Unit Serial Number: 3-H-4-26-45

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 87.0 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc.	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	81.1	MAY 26 1993	22PPG43
Haze:	1.1	MAY 26 1993	22PPG43
Photo (Single Exposure):	22 PPG 47.	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <3 2: <3 3: <3 4: <3	Ø	6-8-93	22 PPG 10
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .678 2: .679 3: .684 4: .683	Acc.	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Rej	JUN 03 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 03 1993	22 PPG 77

(Comments) No seal and bad bumper on outbd side

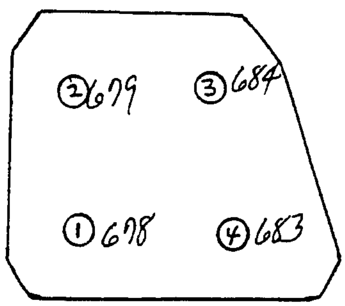
Visual Inspection: (Place comments on attached sheet) Rej JUN 03 1993 22 PPG 77

Visual Inspection Map & Comments

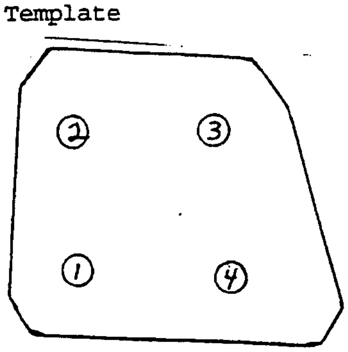


DeLam As marked
Surface scr. As marked
Vinyl crack As marked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-13 Chg. F

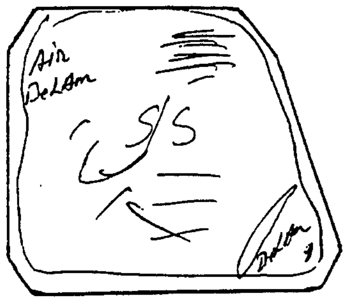
Unit Serial Number: 4-H-10-15-108

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 127.7 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28 22 [illegible]
Insulation Test: (2500 VAC) Power to Metal:	Acc.	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	81.9	MAY 26 1993	22PPG43
Haze:	1.4	MAY 26 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: < 3 2: < 3 3: < 3 4: < 3	acc	6-8-93	22 PPG 10
Dimensional Inspection:		JUN 14 1993	
Unit Thickness: (Per Template) 1: .679 2: .681 3: .686 4: .684	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Rej	JUN 03 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 03 1993	22 PPG 77

(Comments) BAd Seal And Bumper

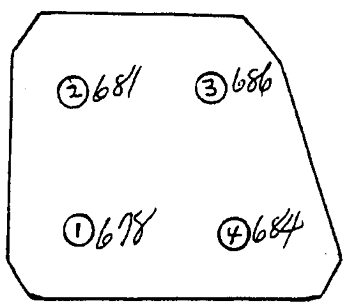
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 03 1993	[illegible] PPG 77

Visual Inspection Map & Comments

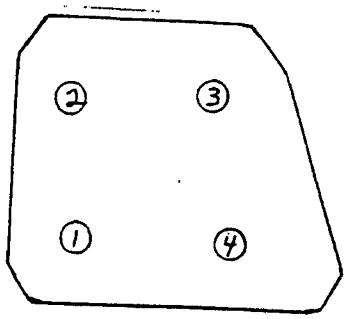


BAd SURfAce SCR LocATed ThROUGhOUT The UNIT
Both Side
AIR And DeLam LocATed ALL AROUND UNIT

Thickness Template



Deviation Template



APPENDIX C
BIRD IMPACT DATA SHEETS

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89364-502 S/N 86-H-10-06-007 Date 6/22/93

Bus to Bus 37.5 OHMS Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.020
Bird Speed (kts)	250.0	251.7

Ambient °F 70°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 783 Test Date: 6/22/93 Tested By: HEG.

Test Results:

OUTBOARD PLY BROKEN. CORE PLY INTACT. SMALL AMOUNT OF BIRD IMPACTED WITNESS PLATE. BIRD ENTERED OVER UPPER EDGE OF WINDOW ON IMPACT. COMPRESSION OF INBOARD MOUNTING O-RINGS PROBABLE CAUSE.

PPG Witness: [signature] Date: 6/22/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-502 S/N 86-H-10-06-30 Date 6/22/93

Bus to Bus 34.8 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250.0	251.1

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 784 Test Date: 6/22/93 Tested By: HEG

Test Results:

NO DAMAGE. SMALL AMOUNT OF BIRD ENTERED OVER TOP EDGE. SAME REASONS AS SHOT # 783.

PPG Witness: H Goodwell Date: 6/22/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-502 S/N 86-H-10-06-22 Date 6/23/93

Bus to Bus 33.6 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250.0	252.8

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 785 Test Date: 6/23/93 Tested By: HEG

Test Results:

NO DAMAGE. NO BIRD RESIDUE ON WITNESS PLATE.

PPG Witness: [signature] Date: 6/23/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-502 S/N 86-H-10-06-096 Date 6/24/93

Bus to Bus 33.5 Delamination chk. Ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73 °F
Temperature O.B.	R.T.	73 °F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	252.6

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 786 Test Date: 6/24/93 Tested By: HEG

Test Results:

NO DAMAGE. NO BIRD RESIDUE ON WITNESS PLATE.

PPG Witness: H Goodwil Date: 6/24/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 83-H-9-19-282 Date 7/19/93

Bus to Bus 41.7 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.001
Bird Speed (kts)	250	249.6

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 792 Test Date: 7/19/93 Tested By: HEG

Test Results:

CORE PLY FAILED. NO SPALL ON WITNESS PLATE.

PPG Witness: H Goodall Date: 7/19/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 83H-8-15-756 Date 7/19/93

Bus to Bus 46.0 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	249.4

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 793 Test Date: 7/19/93 Tested By: HEG

Test Results:

ALL PLIES FAILED. MINOR SPALL ON WITNESS PLATE. NO PENETRATION.

PPG Witness: H Goodrue Date: 7/19/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 84-H-3-19-220 Date 7/20/93

Bus to Bus 44.5 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.000
Bird Speed (kts)	250	250.1

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 794 Test Date: 7/20/93 Tested By: HEG

Test Results:

OUTBOARD PLY FAILED. CORE PLY INTACT.

PPG Witness: H Goodwill Date: 7/20/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 86-H-12-01-146 Date 7/20/93

Bus to Bus 36.5 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	75°F
Temperature O.B.	R.T.	75°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	252.4

Ambient °F ~~CENTER~~ 75°

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 795 Test Date: 7/20/93 Tested By: HEG

Test Results:

NO GLASS BREAKAGE. ALL PLIES INTACT. BENT Z RETAINER BADLY.

PPG Witness: H Goodman Date: 7/20/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 82-H-10-18-107 Date 7/20/93

Bus to Bus 41.3 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	75 °F
Temperature O.B.	R.T.	75°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	249.4

Ambient °F 75°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 796 Test Date: 7/20/93 Tested By: HEG

Test Results:

ALL PLIES FAILED. MINOR SPALL.

PPG Witness: H Goodrie Date: 7/20/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 82-H-9-6-235 Date 7/21/93

Bus to Bus 43.4 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	251.0

Ambient °F 70°F
Impact Loc. CENTER
Installation Angle 45°
Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 797 Test Date: 7/21/93 Tested By: HEG

Test Results:

OUTBOARD PLY FAILED. CORE PLY INTACT

PPG Witness: [signature] Date: 7/21/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501   S/N 83-H-11-21-325   Date 7/21/93

Bus to Bus 45.7   Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES   Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	247.5

Ambient °F 70°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 LWS L.H.

Shot No.: 798   Test Date: 7/21/93   Tested By: HEG

Test Results:

ALL PLIES FAILED. CORE PLY SPALLED BUT NONE ON WITNESS PLATE.

PPG Witness: [signature]   Date: 7/21/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 89-286-140-697 Date 7/22/93

Bus to Bus 38.0 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	65°F
Temperature O.B.	R.T.	65°F
Bird Wt. (lbs)	4.0	4.000
Bird Speed (kts)	250	250.8

Ambient °F 65°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED

Shot No.: 799 Test Date: 7/22/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: H Goodwin Date: 7/22/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89357-1 S/N B75-1149 Date 9/1/93

Bus to Bus 71.1 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	71°F
Temperature O.B.	R.T.	71°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	247.5

Ambient °F 71°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 915 Test Date: 9/1/93 Tested By: HEG

Test Results:

OUTBOARD GLASS FAILED. BIRD PENETRATION BETWEEN O.B. RETAINER & GASKET ALONG AFT EDGE & AT TOP AFT CORNER. BENT 14 MOUNTING BOLTS.

PPG Witness: [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-064-110-471 Date 9/1/93

Bus to Bus 69.8 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	71°F
Temperature O.B.	R.T.	71°F
Bird Wt. (lbs)	4.0	4.020
Bird Speed (kts)	250	251.3

Ambient °F 71°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

NEW #4 WINDOW L.H.

Shot No.: 816 Test Date: 9/1/93 Tested By: HEG

Test Results:

NO DAMAGE. SMALL AMOUNT OF BIRD PENETRATION BETWEEN O.B. RETAINER & WINDOW GASKET. NO BENT BOLTS.

PPG Witness: H. [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-064-H0-473 Date 9/1/93

Bus to Bus 69.4 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	248.9

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

NEW #4 WINDOW L.H.

Shot No.: 817 Test Date: 9/1/93 Tested By: HEG

Test Results:

NO DAMAGE. NO BENT BOLTS. MINOR BIRD PENETRATION AFT EDGE & BOTTOM EDGE.

PPG Witness: [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-059-H0-350 Date 9/1/93

Bus to Bus 70.1 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.020
Bird Speed (kts)	250	225.1

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

Shot No.: 818 Test Date: 9/1/93 Tested By: HEG

Test Results:

NO TEST. MISFIRE. CAMERA FILM BROKE. LARGE GLASS CHIP BLOWN OFF LOWER AFT CORNER OPPOSITE TERMINAL BLOCK. UNIT WILL BE REPLACED BY PPG & DATA REISSUED.

PPG Witness: [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. S-71764-501 S/N 92-025-HO-006 Date 9/29/93

Bus to Bus 69.3 Delamination chk. OK

Requirements:

High Speed Film (~~4~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	248.4

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

NEW #4 WINDOW L.H.

Shot No.: 835 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE.

PPG Witness: H Goodnel Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-119-HO-186 Date 9/29/93

Bus to Bus 64.8 Delamination chk. OK

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	RT.	73°F
Temperature O.B.	RT.	73°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	247.8

Ambient °F 73°F
Impact Loc. CENTER
Installation Angle 58.2°
Sweep Back Angle 35°

NEW #4 WINDOW L.H. – REPLACEMENT FOR SHOT #818

Shot No.: 836 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: [signature] Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 85-11-07-01-276 Date 9/29/93

Bus to Bus OPEN Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	248.7

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 837 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: [signature] Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 90-173-HO-721 Date 9/29/93

Bus to Bus OPEN Delamination chk. OK

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	74°F
Temperature O.B.	R.T.	74°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	247.1

Ambient °F 74°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 838 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: [signature] Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-13 CWC F S/N 5-H-5-23-84 Date 9/30/93

Bus to Bus 118.0 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	251.2

Ambient °F 70°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 839 Test Date: 9/30/93 Tested By: HEG

Test Results:

OUTBOARD PLY BROKEN. NO BIRD PENETRATION.
INTERLAYER TORN IN LOWER FORWARD CORNER.

PPG Witness: [signature] Date: 9/30/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. S-71764-501 CHG. H. S/N 7-H-2-4-35 Date 9/30/93

Bus to Bus 119.8 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	71°F
Temperature O.B.	R.T.	71°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	250.8

Ambient °F 71°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REMAINED #4 WINDOW · L.H.

Shot No.: 840 Test Date: 9/30/93 Tested By: HEG

Test Results:

ENTIRE GLASS SECTION TORN OUT AT INSERT.
PICTURE FRAME REMAINING IN FIXTURE.

PPG Witness: [signature] Date: 9/30/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764 S/N 4-H-10-9-69 Date 9/30/93

Bus to Bus 85.0 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	RT	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	251.0

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 841 Test Date: 9/30/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: [signature] Date: 9/30/93

I

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 82-H-12-6-392 Date 9/30/93

Bus to Bus 79.7 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	250.8

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 842 Test Date: 9/30/93 Tested By: HEG

Test Results:

NO DAMAGE.

PPG Witness: [signature] Date: 9/30/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501   S/N 6-H-12-02-36   Date 10/1/93

Bus to Bus 96.8   Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (2 cameras) YES   Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	250.3

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 843   Test Date: 10/1/93   Tested By: HEC

Test Results:

BOTH GLASS PLIES FAILED. 4" TEAR IN INTERLAYER AROUND LOWER FORWARD CORNER.

PPG Witness: [signature]   Date: 10/1/93

DEVELOPMENT OF REPAIR PROCESSES AND SOURCES FOR C/KC-135 AIRCRAFT WINDOWS/WINDSHIELDS

Battelle
. . . Putting Technology To Work

RICHARD J. OLSON

BATTELLE
505 KING AVENUE
COLUMBUS, OH 43201

SEPTEMBER 1994

TECHNICAL REPORT FOR 09/91 - 01/94
C/KC-135 FINAL REPORT
CONTRACT NUMBER FO9603-90-D-2217-SD02

DISTRIBUTION AUTHORIZATION: APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

PREPARED FOR
OKLAHOMA CITY AIR LOGISTICS CENTER
TINKER AFB, OK 73145

This report is a work prepared for the United States Government by Battelle. In no event shall either the United States Government or Battelle have any responsibility or liability for any consequences of any use, misuse, inability to use, or reliance upon the information contained herein, nor does either warrant or otherwise represent in any way the accuracy, adequacy, efficacy, or applicability of the contents hereof.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
September 1994

3. REPORT TYPE AND DATES COVERED
Technical, C/KC-135 Final Report, 9/01/91 - 01/31/94

4. TITLE AND SUBTITLE
Development of Repair Processes and Sources for C/KC-135 Aircraft Windows/Windshields

5. FUNDING NUMBERS

6. AUTHOR(S)
Richard J. Olson

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Battelle
505 King Avenue
Columbus, Ohio 43201-2693

8. PERFORMING ORGANIZATION REPORT NUMBER
Contract FO9603-90-D-2217-SD02

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Oklahoma City Air Force Logistics Center
OC-ALC/TIETR
3001 Staff Drive, Suite 2AF66A
Tinker AFB, OK 73145-3040

Technology Transition Office
ASC/SMT
2690 C, Suite 5
Wright-Patterson AFB, OH 45433-7412

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
VEP87CR52R1

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 Words)
The U.S. Air Force has historically rejected the notion of using repaired windows/windshields (W/WS). With increasing pressure to reduce fleet operating costs and based on the favorable experience that commercial fleets have had, interest in using repaired W/WS is receiving greater attention. To ensure that repaired W/WS are safe and that they provide similar benefits for the Air Force, a program of evaluation and testing was undertaken to compare new and repaired C/KC-135 W/WS. Optical and electrical properties, pressure integrity, and bird impact resistance of repaired and new W/WS have been evaluated. The bird impact test results are the first data that the Air Force has collected for C/KC-135 W/WS. The functional testing indicated that repaired W/WS are not equal to new W/WS; the new W/WS outperform the repaired W/WS. In terms of removal for cause criteria and absolute performance requirements, however, the repaired W/WS appear to be "good enough." Concerning costs, the direct costs for repair of the W/WS in this program ranged from 65-75% of new W/WS cost, suggesting that money can be saved.

14. SUBJECT TERMS
Aircraft Transparencies, C/KC-135, Windows/Windshields, Repairs, Pressure Cycle Testing, Falling Ball Impact Testing, Bird Impact Testing, Repaired Window/Windshield Costs Analysis

15. NUMBER OF PAGES
264

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

This page intentionally left blank.

TABLE OF CONTENTS

REPORT DOCUMENTATION PAGE iii

TABLE OF CONTENTS v
LIST OF TABLES vi
LIST OF FIGURES vii
SUMMARY x
PREFACE xii

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Objective 1
1.3 Approach 1
1.4 Report Contents 2

2.0 PROTOTYPE SELECTION 3
2.1 C/KC-135 W/WS 3
2.2 Program Prototypes 5
2.3 C/KC-135 #1 and #4 W/WS 5

3.0 W/WS REPAIRS 6
3.1 Aircraft W/WS Damage 6
3.2 Repair Vendors 8
3.2.1 NORDAM Transparency Division 8
3.2.2 Perkins Aircraft Services, Inc. 8
3.2.3 The Glass Doctor 9
3.3 Repair Details 9

4.0 PERFORMANCE TESTING 10
4.1 Test Philosophy 10
4.2 Quality Assurance 12
4.3 General Inspection 12
4.3.1 Test Procedures 12
4.3.1.1 General Visual Examination 13
4.3.1.2 W/WS Dimensional Measurements 14
4.3.1.3 Basic Electrical Measurements 14
4.3.1.4 Heater Operation Tests 14
4.3.1.5 Optical Performance 15
4.3.2 General Inspection Test Results 16
4.4 Pressure Integrity 17
4.4.1 Test Procedures 17
4.4.1.1 Proof Pressure Test 17
4.4.1.2 Cyclic Durability Test 17

TABLE OF CONTENTS
(Continued)

4.4.2 Test Facility 18
4.4.3 Test Results 19
4.5 Residual Strength Assessment 20
4.5.1 Test Procedures 20
4.5.2 Test Facility 20
4.5.3 Test Results 20
4.6 Bird Impact Testing 21
4.6.1 Test Procedures 21
4.6.2 Test Facility 21
4.6.3 Test Results 22
4.7 Performance Testing Summary 23

5.0 COST ANALYSIS 24
5.1 Repair Costs 24
5.2 Costs of New W/WS 24
5.3 Cost Comparison 24

6.0 CONCLUSIONS, RECOMMENDATIONS, and DISCUSSION 25
6.1 Conclusions 25
6.2 Recommendations 27
6.3 Discussion 29

7.0 REFERENCES 31

APPENDIX A. REPAIR VENDOR AIR AGENCY CERTIFICATES A-1
APPENDIX B. GENERAL INSPECTION DATA SHEETS B-1
APPENDIX C. BIRD IMPACT DATA SHEETS C-1

LIST OF TABLES

Table 2.1 C/KC-135 W/WS Part Numbers 33
Table 2.2 C/KC-135 Program W/WS 33
Table 2.3 C/KC-135 #1 and #4 W/WS Dimensions 36
Table 3.1 C/KC-135 Repaired and Not Repaired #1 W/WS in the Test Program . . . 37
Table 3.2 C/KC-135 Repaired and Not Repaired #4 W/WS in the Test Program . . . 38
Table 4.1 C/KC-135 #1 W/WS General Examination and Dimensional Measurements Test Results 39
Table 4.2 C/KC-135 #4 W/WS General Examination and Dimensional Measurements Test Results 41
Table 4.3 C/KC-135 #1 W/WS Basic Electrical Measurements Test Results 43

LIST OF TABLES
(Continued)

Table 4.4 C/KC-135 #4 W/WS Basic Electrical Measurements Test Results 44
Table 4.5 C/KC-135 #1 W/WS Heater Operation Test Results 45
Table 4.6 C/KC-135 #4 W/WS Heater Operation Test Results 46
Table 4.7 C/KC-135 #1 W/WS Optical Performance Test Results 47
Table 4.8 C/KC-135 #4 W/WS Optical Performance Test Results 48
Table 4.9 C/KC-135 #1 W/WS Pressure Integrity Test Results 49
Table 4.10 C/KC-135 #4 W/WS Pressure Integrity Test Results 50
Table 4.11 C/KC-135 #1 W/WS Residual Strength Ball Drop Test Results 51
Table 4.12 C/KC-135 #4 W/WS Residual Strength Ball Drop Test Results 52
Table 4.13 C/KC-135 #1 W/WS Bird Impact Test Results 53
Table 4.14 C/KC-135 #4 W/WS Bird Impact Test Results 54
Table 4.15 C/KC-135 W/WS General Inspection Summary 55
Table 4.16 C/KC-135 W/WS Pressure Integrity Test Summary 56
Table 4.17 C/KC-135 W/WS Ball Drop Residual Strength Test Summary 56
Table 4.18 C/KC-135 W/WS Bird Impact Test Summary 57
Table 4.19 C/KC-135 #1 W/WS Mounting Edge Measurements and Bird Impact Test Results 58
Table 5.1 Initial C/KC-135 W/WS Repair Estimates 59
Table 5.2 C/KC-135 #1 W/WS Actual Repair Costs 60
Table 5.3 C/KC-135 #4 W/WS Actual Repair Costs 61
Table 5.4 Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS 62
Table 5.5 C/KC-135 New W/WS Costs 65
Table 5.6 Repair Cost Comparison Data for C/KC-135 W/WS 65

LIST OF FIGURES

Figure 2.1 C/KC-135 W/WS Identification 66
Figure 2.2 C/KC-135 W/WS Construction 67
Figure 2.3 W/WS Construction Showing Location of Slip Planes 68
Figure 2.4 C/KC-135 #1 W/WS Cross-Section 69
Figure 2.5 C/KC-135 #4 W/WS Cross-Section 70
Figure 3.1 The Glass Doctor Patented Technique for Repair of Conical Cracks in Laminated Glass, U.S. Patent # 3,841,932 71
Figure 3.2 The Glass Doctor Patented Technique for Repair of Delaminations, U.S. Patent # 4,780,162 72
Figure 4.1 C/KC-135 #1 W/WS Thermal Images From the Heater Test 73
Figure 4.2 C/KC-135 #4 W/WS Thermal Images From the Heater Test 74
Figure 4.3 Worst Optical Distortion Found in Any C/KC-135 #1 W/WS (S/N 83-H-11-7-432) 75

LIST OF FIGURES
(Continued)

Figure 4.4 Worst Optical Distortion Found in Any C/KC-135 #4 W/WS (S/N 87-H-04-20-130) 76
Figure 4.5 Pressure Integrity Testing Facility 77
Figure 4.6 C/KC-135 #1 W/WS Pressure Integrity Mounting Frame 78
Figure 4.7 C/KC-135 #4 W/WS Pressure Integrity Mounting Frame 79
Figure 4.8 C/KC-135 W/WS Mounting Details 80
Figure 4.9 Typical C/KC-135 #1 W/WS Pressure Integrity Test Set Up 81
Figure 4.10 Typical C/KC-135 #4 W/WS Pressure Integrity Test Set Up 82
Figure 4.11 Worst Delamination Observed in a C/KC-135 #1 W/WS From Pressure Cycling (Repaired W/WS, S/N 82-H-09-06-537) 83
Figure 4.12 Worst Delamination Observed in a C/KC-135 #4 W/WS From Pressure Cycling (Repaired W/WS, S/N 5-H-12-16-47) 84
Figure 4.13 Residual Strength Falling Ball Test 85
Figure 4.14 #1 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Consequences of Two Ball Drops (New W/WS, S/N 86-H-10-06-062)86
Figure 4.15 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Outboard View (S/N 82-H-9-6-537) 87
Figure 4.16 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Inboard View (S/N 82-H-9-6-537) 88
Figure 4.17 #4 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Test Result (New W/WS, S/N 92-093-HO-388) 89
Figure 4.18 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Outboard View (S/N 5-H-12-16-47) 90
Figure 4.19 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Inboard View (S/N 5-H-12-16-47) 91
Figure 4.20 C/KC-135 #1 W/WS Bird Impact Mounting Frame 92
Figure 4.21 C/KC-135 #4 W/WS Bird Impact Mounting Frame 93
Figure 4.22 C/KC-135 #1 W/WS Mounting Hardware Details 94
Figure 4.23 Schematic of the PPG Bird Cannon 95
Figure 4.24 Support Frame Used for Bird Impact Testing for C/KC-135 W/WS 96
Figure 4.25 Typical Pre-Test View of C/KC-135 #1 W/WS (Copilot) Prior to Bird Impact Testing 97
Figure 4.26 Typical Pre-Test View of C/KC-135 #4 W/WS (Pilot) Prior to Bird Impact Testing 98
Figure 4.27 Bird Impact Test Set Up Showing Impact Velocity Timing Trap (Right) and Front High Speed Film Camera Equipment (Center) 99
Figure 4.28 Bird Impact Spall Sheet Viewed From Behind a C/KC-135 #1 W/WS 100

LIST OF FIGURES
(Continued)

Figure 4.29 C/KC-135 #1 W/WS Showing No Damage From a 4-Pound Bird Impact at 250.8 Knots (Repaired W/WS, S/N 89-286-HO-697) 101
Figure 4.30 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Front View (New W/WS, S/N 86-H-10-06-007) 102
Figure 4.31 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Rear View (New W/WS, S/N 86-H-10-06-007) . 103
Figure 4.32 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Front View (Repaired W/WS, S/N 82-H-10-18-107) 104
Figure 4.33 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Rear View (Repaired W/WS, S/N 82-H-10-18-107) 105
Figure 4.34 Spall Sheet Condition From a 4-Pound Bird Impact at 249.4 Knots on a C/KC-135 #1 W/WS With All Glass Plies Failed (Repaired W/WS, S/N 82-H-10-18-107) 106
Figure 4.35 C/KC-135 #4 W/WS Showing No Damage From a 4-Pound Bird Impact at 248.7 Knots (Not Repaired W/WS, S/N 4-H-10-9-69) 107
Figure 4.36 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Front View (Repaired W/WS, S/N B75-1149) . . 108
Figure 4.37 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Rear View (Repaired W/WS, S/N B75-1149) . . 109
Figure 4.38 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Front View (Not Repaired W/WS, S/N 7-H-2-4-35) 110
Figure 4.39 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Rear View (Not Repaired W/WS, S/N 7-H-2-4-35) 111
Figure 4.40 Spall Sheet and W/WS Condition From a Catastrophic 4-Pound Bird Impact at 250.8 Knots on a C/KC-135 #4 W/WS (Not Repaired W/WS, S/N 7-H-2-4-35) 112
Figure 6.1 Heat Strengthened Glass Residual Stresses 113

SUMMARY

The Air Force, in trying to reduce fleet maintenance costs, is considering using repaired windows/windshields (W/WS). Based on reported cost savings and favorable experience that commercial fleets have had with repaired W/WS, the use of repaired W/WS seems very attractive. Before adopting an operating policy to use repaired W/WS, however, the Air Force decided that structural performance testing of repaired W/WS and a cost analysis were required.

The approach followed for evaluating whether the use of repaired W/WS is justified was to procure some used C/KC-135 W/WS, make repairs on them, and then subject the repaired W/WS to a series of tests to determine the difference in performance when compared with new W/WS. The cost to make the repairs provides the data for the cost benefit analysis. The test results provide the data for an evaluation of fitness for purpose of repaired W/WS.

The testing conducted for this program represents the first full-range, systematic testing of the structural integrity of repaired W/WS for transport-type aircraft. Optical and electrical properties, pressure integrity, and bird impact resistance have been evaluated. In addition, the bird impact test results are the first data that the Air Force has collected for C/KC-135 W/WS.

The test results indicate that repaired W/WS have been restored to a condition better than the prevailing C/KC-135 Technical Order replacement criteria, but they do not perform as well as new W/WS. Many of the repaired W/WS still contain defects that would not pass an OEM quality assurance inspection. Some delamination occurred in a few of the repaired W/WS during pressure cycling, but it was not severe. The residual strength of the pressure cycled W/WS tends to suggest that the repaired W/WS are not quite as good as new W/WS. The bird impact test results are quite clear - new W/WS outperform either repaired or unrepaired W/WS. At the 250 knot impact velocity used in this program, all of the new and repaired #1 and #4 W/WS do, however, meet the no bird penetration requirement, while two of the repaired #1 W/WS technically failed the no spall criterion. From a practical viewpoint, the spall was very modest. One W/WS that was not repaired because of an out of specification heater resistance, failed catastrophically in the bird impact test.

Although repaired W/WS do not perform as well as new W/WS, they were, in fact, restored to a condition better than the prevailing C/KC-135 Technical Order W/WS replacement criteria. On the basis of the fact that they would not be removed from service if found on an aircraft, and the fact that they prevented bird penetration, repaired W/WS appear to be "good enough," at least at a 250 knot bird impact velocity.

The cost analysis indicates that savings may be realized. For this program, the cost of making the repairs was 75-percent of the new W/WS purchase price for #1 W/WS and 65-percent for the #4 W/WS. Considering all five of the C/KC-135 W/WS types and the full

range of estimates, quotes, and actual costs, repairing a C/KC-135 W/WS might cost as little as 41-percent of a new W/WS, but it could also cost as much as 132-percent.

The cost savings are only the direct repair costs. To this must be added the direct cost of transportation and the indirect costs of procuring the service (contracting), administrating it (accounts payable, records management, etc.) and operating it (storage, shipping and handling, outgoing/incoming inspection, etc.). Offsetting these items are a reduced burden, both economic and environmental, from lower landfill costs for W/WS that are taken out of service. These factors will certainly impact the economics and to ignore them would be a false economy. The Air Force should do a complete cost/benefit analysis to satisfy themselves that there is a true economic advantage to using repaired W/WS.

A significant peripheral finding from this study is that a blanket 10-year transport-type aircraft W/WS replacement policy cannot be justified, if W/WS manufacture date is used as the indicator of age. The new W/WS used in this program were manufactured in 1986, and they showed no evidence of degradation due to being in storage for 7 years. To remove and replace these W/WS in 1996, solely on the basis of age, would be wasting operating and maintenance dollars. A better scheme for tracking service history and a service-history-based replacement criterion must be devised for a blanket W/WS replacement policy.

Recommendations that can be made as a result of the work performed on this program are contingent upon the Air Force making a decision, based on the available data, that the performance of repaired W/WS is acceptable. If, in the opinion of the Air Force, the performance of repaired W/WS is deemed "good enough," recommendations are made for approved W/WS repair vendors and repair processes. Recommendations for operating a W/WS repair program are also made.

PREFACE

The work reported herein was performed by Battelle, Columbus, Ohio, under Air Force Contract FO9603-90-D-2217-SD02, "Development of Repair Processes and Sources for C/KC-135 and B-52 Aircraft Windows/Windshields." The program was directed by the Oklahoma City Air Logistics Center (OC-ALC) at Tinker Air Force Base. Air Force administrative direction was provided by Ms. Cindy Cooper, OC-ALC/LADCB. Air Force technical direction was provided by Mr. Robert Koger, OC-ALC/TIETR.

The work was performed during the period of September 1991 to January 1994. The technical program at Battelle was directed by Mr. Richard Olson of Battelle's Engineering Mechanics Department and Mr. Dennis Miller of Battelle's Polymer Center. The author wishes to acknowledge Mr. Herb Goodrich of PPG Industries, Inc. Aircraft Products Division in Huntsville, Alabama for coordinating and conducting the W/WS testing, and Mr. Ryan Rice at Battelle for preparation of the manuscript.

1.0 INTRODUCTION

1.1 Background

Several facilities exist for repairing aircraft windows/windshields (W/WS), and with U.S. Federal Aviation Authority (FAA) approval, many commercial airlines are currently utilizing these services. The cost of repairing a W/WS is substantially less than the purchase price of a new W/WS for commercial fleets, so the incentive for them to use repaired W/WS is large. The favorable experience that the commercial fleet has had with repaired W/WS suggests that they will continue to use repaired W/WS in the foreseeable future.

The U.S. Air Force has historically rejected the notion of using repaired W/WS. With decreasing Congressional funding for the military, measures to reduce fleet operating costs are receiving greater scrutiny. Based on the experience that the commercial fleet has had with repaired W/WS, the issue of using repaired W/WS on military aircraft is now being systematically considered. To ensure that repaired W/WS are safe and that they provide a similar cost savings benefit to the Air Force, a program of thorough evaluation and testing was required.

In September 1991, the Air Force contracted with Battelle to investigate the consequences and impact of using repaired W/WS. The program was to evaluate feasibility by testing the functional performance of repaired W/WS and by performing an economic analysis. Adequate functional performance and a favorable economic analysis would then provide the justification for a recommendation to use repaired W/WS.

The maintainability of Air Force fleet aircraft is an on-going concern because many of the aircraft in the current inventory are projected to have significant roles for many more years (10 to 20 years). By decreasing the lead time and procurement costs for W/WS, the maintainability of the fleet is enhanced. Furthermore, by gaining more control over the spare parts inventory, fewer new parts will be required and the costs of the W/WS program will be reduced.

1.2 Objective

The objective of this program was to provide a rationale for either accepting or rejecting the use of repaired W/WS in Air Force fleet aircraft.

1.3 Approach

The approach followed for evaluating whether use of repaired W/WS is a viable option for the Air Force was to procure some used W/WS, make prototypical repairs on them, and then subject the repaired W/WS to a battery of tests to see if there is any difference in performance when compared with new W/WS. Making prototypical repairs provides

baseline data for repair costs. The battery of tests provides an evaluation of fitness for purpose of the repaired W/WS.

The W/WS selected for evaluation in this program were from C/KC-135 aircraft. These W/WS are of typical laminated glass and plastic construction and include integral heaters. Repairs considered in this program included surface damage, delamination, electrical heater problems, broken layers, and seal/mounting problems. Repairs were subcontracted to commercial fleet W/WS repair stations with instructions to return repairable W/WS to Original Equipment Manufacturer (OEM) specifications per the approved processes in the repair vendor's FAA W/WS Air Agency Certificates. The direct costs for performing the repairs on the test prototypes forms the foundation of the economic analysis.

The approach to evaluating the functional performance of the repaired W/WS involved a rigorous set of tests designed to determine if the repair processes have degraded the W/WS when compared with new W/WS. Both repaired and new W/WS were subjected to pressure, impact, optical, and heater operation tests, similar in spirit to W/WS qualification tests. Provided that the repaired and new W/WS perform the same, the use of repaired W/WS can, at least on a performance basis, be justified.

1.4 Report Contents

In the sections that follow, the results of this 2½-year study are presented. The report begins with a discussion of the selection of repair candidate prototypes for the program and ends with recommendations for the Air Force on implementing a W/WS repair program. Topics presented include:

- C/KC-135 W/WS construction details
- Selection and condition of the W/WS repaired in this program
- A generic discussion of glass-laminate aircraft W/WS repairs, identification of the repair vendors that were involved with this program, and details of the actual repairs made to the W/WS
- Repaired W/WS performance evaluation, including test procedures, pass/fail criteria, and test results
- A cost analysis
- Conclusions and recommendations.

2.0 PROTOTYPE SELECTION

The C/KC-135 aircraft was selected as the prototype for evaluating the feasibility of using repaired W/WS because the number of aircraft in the fleet is fairly high, the C/KC-135 is projected to be in service for many more years, and because the repair vendors have direct experience repairing the essentially equivalent Boeing 707 W/WS. The C/KC-135 has 10 cockpit W/WS identified in Figure 2.1, 5 on the pilot side and 5 on the copilot side. The set of five W/WS on the copilot side are a mirror image of the pilot side W/WS. W/WS #1 is the forward W/WS, #2 and #3 are side W/WS, and #4 and #5 are eyebrow W/WS. All of the W/WS except #2 are fixed in position. W/WS #2 opens to provide ventilation and ground communication by sliding aft on a track. Table 2.1 lists the current part numbers for the C/KC-135 W/WS.

2.1 C/KC-135 W/WS

Figure 2.2 shows the general construction of the C/KC-135 W/WS. The C/KC-135 W/WS have a three-part glass and vinyl laminate construction. The inner layer is thick, heat-strengthened plate glass designed to withstand cabin pressure forces. A transparent, plasticized, polyvinyl butyral core layer acts as the "fail-safe" load carrying member and prevents shattering in the event of inner ply failure. The outer ply is a relatively thin layer of heat-strengthened glass with no structural significance, but it provides rigidity and a scratch-resistant surface. A phenolic or masonite filler strip, located around the edge of the W/WS, and a metal filler strip embedded in the vinyl provide the means to attach the W/WS to the airframe. Vinyl or vinyl and rubber bumpers protect the sides of the outer ply.

The structural integrity design of C/KC-135 cockpit W/WS is based on two requirements: "fail-safe" pressure integrity and bird impact resistance. The "fail-safe" pressure integrity is founded on two redundant systems, an inner glass ply that can sustain the full rated cabin pressure in the absence of all other layers, and a polymeric core ply that can maintain pressure integrity if the inner and outer glass plies are cracked. The bird impact structural integrity of W/WS is either characterized as "bird bagging" or "bird bounce." Bird bagging W/WS, typically two glass layers with a polymeric core ply, stop bird penetration by large ductile deformation of the core ply, i.e., "bagging" the bird. Bird bounce W/WS are typically multilaminates and cause the bird to "bounce" off the W/WS. The C/KC-135 W/WS main cockpit W/WS are "bird bagging" W/WS.

The glass used in C/KC-135 W/WS is heat strengthened to provide resistance to cracking. The glass is heated to near the softening point and then quenched to produce compressive residual stresses that extend from the outer surface into a depth of about $1/6^{th}$ of the glass thickness. Below the compressive stress layer lies tensile residual stresses. As long as surface defects do not penetrate into the tensile layer, the glass will exhibit a high resistance to fracture. Once a crack does fully penetrate the tensile layer, the glass will shatter as the tensile stresses are relieved.

The vinyl core, which acts as the "fail-safe" pressure boundary and means for controlling glass fragments in the event of a glass ply failure, is highly plasticized polyvinyl butyral. The vinyl is relatively brittle at low temperatures (-65° F), and unable to absorb much energy per unit volume. At temperatures approaching 130° F, the vinyl becomes very ductile and can absorb a relatively large amount of energy as it is loaded. W/WS heaters, which not only de-fog and de-ice the glass, ensure that the vinyl remains ductile.

An integral part of the C/KC-135 W/WS construction is slip planes or a parting medium at the edges of the glass. A slip plane is located between both the inner glass ply and the vinyl and the outer glass ply and the vinyl as shown in Figure 2.3. The slip planes are thin strips of material at the glass-vinyl interface that keep the glass from bonding to the vinyl. This allows the various plys to move independently at these locations in response to pressure loads and differential thermal expansion. Without the slip planes, the glass at the edges of the W/WS would be prone to fracture because it would exceed its strain limit as it tried to move with the underlying vinyl. The slip planes form a "softer" connection that promotes a more gradual build up of strains in the glass so that it does not exceed its strain capacity. Although the slip planes look similar to delamination, they are not defects but an intentional part of the W/WS design.

The C/KC-135 cockpit W/WS contain heating systems for anti-icing and/or anti-fogging. An electrically conductive film of pyrolytic tin oxide between the outer ply and vinyl core ply is used to heat the #1 and #2 W/WS to reduce ice/frost formation. A similar conductive film between the inner ply and core ply is used on #3, #4, and #5 W/WS for defogging only. The W/WS heating system, so called NESA® coated glass, uses the resistivity of the film to provide the heating. The #1 W/WS also contain fine wires at the W/WS edges between the outer glass ply and vinyl, so-called edge heaters, to correct a heating power deficiency in the corner. The temperature of the #1 and #2 W/WS is controlled with an integral sensor. Externally applied thermal switches control the temperature of #3, #4, and #5 W/WS.

A temperature sensor embedded in the laminate of the #1 W/WS regulates the temperature of the #1 and #2 W/WS when the heater is on. The sensor, a negative temperature coefficient (NTC) thermistor, exhibits increasing resistance with increasing temperature. When wired in an appropriate power amplifier control circuit, as the W/WS and sensor temperature rises, the sensor resistance increases. This causes the control amplifier to shut off current to the W/WS, and hence power dissipated by the heater film, thus reducing the temperature. When the temperature drops below a lower setpoint, the control amplifier turns power back on to the W/WS.

Seals on the W/WS keep cabin pressure in and moisture out. In addition, they act as vibration and shock absorbers and help to compensate for differential thermal expansion. W/WS #3, #4, and #5 utilize a silicone rubber molded-in-place pressure seal that is molded to the W/WS mounting surface. Drawing the W/WS tight to the airframe with its mounting bolts effects the seal. On the #2 W/WS, a bellcrank mechanism presses the W/WS against the airframe when it is closed and latched. The #1 W/WS uses a molded-in-place seal similar the other W/WS, except that a stainless steel Z-channel is sandwiched between a

silicon rubber cushion and a beaded pressure seal. The mounting bolts provide the pressure to hold the W/WS tight against the airframe. All of the C/KC-135 W/WS mount from the inside of the aircraft.

2.2 Program Prototypes

OC-ALC made arrangements to have C/KC-135 W/WS that were removed from fleet aircraft at Tinker AFB shipped to Battelle. Over 100 W/WS were screened to find 75 prototype repair candidates. All five C/KC-135 W/WS types were included in the 75 W/WS population. At the time of their removal, the W/WS were judged not serviceable per the criteria of the applicable C/KC-135 Fuselage Window Tech Order, Section 8 of T.O. 1C-135(K)A-2-2. Indicated reasons for removal from service included: failed heaters, bubbles, scratches, separation, leaks, old, discolored, and corrosion.

The service history of the prototype repair candidates is not known because: 1) very few of the W/WS had airframe numbers, 2) W/WS are not tracked by serial number, and 3) planes are moved from location to location as a part of normal squadron rotation. In most instances, the date of removal from service was not noted. The installation date is not known for any of the W/WS. All that is known for certain is the year the W/WS was made; the first one or two digits of the serial number indicate the year the W/WS was made - a single digit is a 1970's vintage W/WS.

Table 2.2 lists the type, serial number, and condition of the 75 C/KC-135 repair candidates. W/WS that have serial numbers that begin with numbers were made by PPG, while those that start with letters were made by Libbey-Owens-Ford.

At the outset of the program, the plan was to repair and test some of each of the five different C/KC-135 W/WS. A large number of the repair prototype candidate W/WS, however, were judged not repairable by virtue of out-of-specification or open circuit heaters. In conjunction with OC-ALC, the decision was made to proceed with repairing and testing only #1 and #4 W/WS. Although other repair candidates could have been obtained, it was felt that the program objectives could be adequately met if only two of the five W/WS types were evaluated. The #1 and #4 W/WS were selected because they have construction (and consequently repairs) that is typical of all of the C/KC-135 W/WS, there was enough W/WS in the population to conduct all of the tests in the test matrix, and the #1 and #4 W/WS are the only reasonable bird impact test candidates.

2.3 C/KC-135 #1 and #4 W/WS

Table 2.3 lists the general dimensions for the #1 and #4 W/WS. The #1 W/WS is a flat, nearly rectangular W/WS. The #4 W/WS, on the other hand, is roughly square in the plan view and has curvature (approximately 0.65 inches out of plane across the largest diagonal in the viewing area). The general construction was noted in Section 2.1. Figures 2.4 and 2.5 show detailed cross-sections of the #1 and #4 W/WS.

In general, because the #1 W/WS is flat, it is one of the easiest W/WS to manufacture and repair. Being flat, the optics of #1 W/WS are very good. The curvature on the #4 W/WS tends to result in some degree of optical distortion, and the curvature makes it somewhat more difficult than a #1 to repair, in spite of its small size.

3.0 W/WS REPAIRS

3.1 Aircraft W/WS Damage

The most common failure modes of laminated transparencies are:

- Delamination: separation of vinyl from the glass
- Cracks and chipping: glass breakage due to high stress
- Arcing: unbalanced electrical potential within the conductive coating
- Heater Failure: loss of continuity in the heater or heater sensor circuit
- Impaired Vision: surface scratches, contaminates, or internal defects
- Contamination: air or water leaks caused by defective seals
- Vinyl cracking.

Delamination is separation of the glass surface of the inner or outer ply from the vinyl core ply to which it is bonded. Delamination generally starts at the slip planes and moves inward, although it may occur anywhere in the W/WS. It mainly occurs between the outer ply and the vinyl ply. Delamination does not dramatically reduce the strength of the W/WS, but may interfere with vision or W/WS heating if the delamination occurs at the interface where the heating film is located.

Cracks and chips may occur in either of the glass plys and may be caused by impacts or by high stresses at the edges of the glass. Single cracks in the outer ply are unlikely because the temper in this layer precludes a single crack. After the momentary appearance of a crack in the outer layer, the entire layer shatters very abruptly. Small cracks very near the edges of the W/WS may not be cause for removal, provided the crack is not directed toward the center of the pane. Cracks that adversely affect the functioning of the heater would not be acceptable. Chips may occur internally or externally. Internal chips are caused by the glass-vinyl bond strength exceeding the strength of the glass. External chips are generally caused by impacts. Chips usually have a clamshell shape, are rough, and white powdered glass is often in evidence. Chips are detrimental to the strength of the pane.

W/WS busbar breakdown and faults in the heater film cause arcing. Basically, the insulation breaks down and the heater electrical current short circuits to the airframe. Arcing is evidenced by burned areas around electrical braid and along the busbar.

The failure of the W/WS heater to de-ice or defog satisfactorily is one of the most serious failure modes. Arcing, chips, cracks, or lack of continuity in the heater film that render the heater inoperative are cause for W/WS replacement. Uneven heating or hot spots caused by delamination at the glass-vinyl interface with the heating film or chips may also be a cause for removal.

Satisfactory optical properties of the W/WS are paramount. Foggy or cloudy areas may appear in areas where moisture has penetrated the vinyl and has begun to degrade it. Scratches may occur on both the inner and outer plys that may interfere with visibility. Likewise, delamination may become serious enough to warrant replacement of the W/WS on the basis of reduced visibility. Bubbles may occur in the vinyl core ply in W/WS that have been exposed to elevated temperatures. Bubbles are caused by gas liberated from the vinyl, and grow in size and number with increased temperature or longer exposures. Needless operation of the heaters on the ground is a prime cause of bubbles. Bubbles do not have a large effect on strength of the W/WS, but may become serious enough to impair visibility. Although other failure modes may not be evident, poor optical performance is always a sufficient cause for W/WS replacement.

The bumpers on the edge of the outer glass form a moisture barrier. Degradation of the bumper in the form of cracking or separation from the edge of the outer glass ply can allow moisture and air to get into the slip planes. Moisture can degrade the heater film with consequent initiation of heater failure, arcing, delamination, and contamination.

As a result of aging, cracks may occur in the vinyl. Over time, attack by ultraviolet radiation and high temperatures also causes the vinyl to lose ductility. Eventually, cracks may form around the periphery of the W/WS in proximity to the metal insert as the glass and vinyl try to move relative to one another. Vinyl cracks significantly weaken the structure of the W/WS by putting flaws directly in the load path between the transparency and the airframe for bird impact loads. Per Figures 2.4 and 2.5, only the vinyl extends out to the mounting holes, not the glass. Therefore, if the vinyl is cracked near the metal insert, the W/WS could just "punch out" of the frame into the cabin. The vinyl layer is also the pressure "fail-safe" layer, so vinyl cracks are quite important.

In addition to cracking, the vinyl layer may discolor or darken if it is subjected to temperature in excess of 225 F. Foreign substances in the glass-vinyl interface, either from in-service conditions or introduced as a part of a repair process, may also cause discoloration.

3.2 Repair Vendors

3.2.1 NORDAM Transparency Division

NORDAM Transparency Division is one of the world's largest, privately-held, FAA-approved transparency repair stations. They provide comprehensive overhaul capabilities on glass and acrylic W/WS. Located in Tulsa, Oklahoma, NORDAM has more than 15 years experience in the repair and overhaul of aircraft W/WS.

Repairs that NORDAM is authorized to make include relaminating, surface polishing, and seal rehabilitation. Autoclave curing of delamination, bubbles, voids and interlayer vinyl cracking is done with the same laminating cycles, times and methods utilized in the original manufacture of the W/WS. Polishing includes removal of scratches, chips and pits from the outer glass or acrylic plies. Original optimum optics are restored with the least amount of surface removal, in accordance with strict adherence to OEM manual limits for removal. Seal rehabilitation includes cleaning, repairing, or replacing of seals as required. NORDAM is authorized by the FAA under Air Agency Certificate EZ22812K to make the W/WS repairs. Appendix A has a copy of the certificate.

In addition to their W/WS repair business, NORDAM also manufactures W/WS, cockpit side panels, canopies, cabin windows, wing tip lenses and landing light covers for commercial, regional, military, helicopter, and general aviation aircraft. Products made from stretched and cast acrylic, polycarbonate, and glass are made in either monolithic or laminated configurations.

3.2.2 Perkins Aircraft Services, Inc.

Perkins Aircraft Services, Inc. specializes in the overhaul and repair of both monolithic and laminated aircraft transparencies made of glass or acrylic. Located in Ft. Worth, Texas, Perkins is an FAA-approved repair facility authorized to make in-plant and "on the aircraft" repairs.

A five-step process is used by Perkins to restore damaged W/WS to an FAA-serviceable condition. First, all incoming W/WS are given a thorough inspection to determine whether the W/WS can be repaired. W/WS with out-of-specification electrical systems or that are otherwise judged unrepairable are rejected and returned. The second step of the process is repair of delamination. Using a proprietary autoclave process, the W/WS are heated and pressed to rebond the W/WS layers. Polishing, the third step in the W/WS repair process, is done to remove scratches, chips, and in the case of plastic W/WS, crazing, using automated polishing machines. The fourth step is reassembly. In this step, the transparencies are matched up to their original frames, as applicable, and seals and gaskets are replaced. The final step in Perkins' W/WS repair process is to perform a quality assurance inspection to ensure that all of the necessary repairs have been made and that the

W/WS has been restored to OEM specifications. Perkins holds FAA Air Agency Certificate JKQR257L, see Appendix A, which authorizes them to operate their W/WS repair station.

3.2.3 The Glass Doctor

The Glass Doctor of St. Petersburg, Florida got into the aircraft transparency repair business in 1979 after working in the automobile windshield repair business for 10 years. Starting with cabin window repairs, the business has expanded to also include FAA-approved repair of all cockpit W/WS as well as cabin windows.

The Glass Doctor has developed special techniques for repairing chips, nicks, and delaminations in W/WS. Unlike the other aircraft W/WS repair vendors, The Glass Doctor does not rely solely upon polishing and re-autoclaving of the W/WS to effect the repairs. As described in U.S. patents #3,841,932, #3,914,145, and #4,780,162, The Glass Doctor repairs conical cracks by filling the crack with a polymerizable resin that is vibrated into place by motion of the conical plug, see Figure 3.1. Delamination repairs are made by injecting an adhesive between the delaminated plys per Figure 3.2. Polishing for scratch and distortion removal is also done. Using experience gained from their delamination repair techniques, The Glass Doctor has also developed the unique capability to replace failed W/WS heater sensors and can repair open or arcing busbars. Failed heater sensors are replaced by drilling into the vinyl and potting a new sensor in the hole. Open or arcing busbars are repaired by injecting a conductive adhesive material at the glass-vinyl interface where the busbar defect is located. Although there is some controversy in the aircraft W/WS repair industry associated with the repairs that The Glass Doctor makes, repairs are under warranty for up to 3 years (scratches excluded), and the reported rate of warranty work is very low.

The Glass Doctor operates its W/WS repair station under FAA Air Agency Certificate OX4R430M. A copy of The Glass Doctor's certificate is attached in Appendix A.

3.3 Repair Details

Some of the damage described in Section 3.1 can be repaired. To test the capabilities of the repair vendors to return W/WS to a serviceable condition, contacts at the three repair vendors were established to solicit their interest in participating in this program. Participation in the program was on a paid basis, with the stipulation that the Air Force, through Battelle, had to know something about the repair processes for quality control reasons. In particular, if the repair processes deviate from the processes used in the original manufacture of the W/WS, the Air Force felt that they needed a specification to ensure that they get the same product each time they buy.

In making arrangements for the repairs, Battelle was to sign confidential disclosure agreements with the repair vendors that would prohibit Battelle from disclosing trade secrets and process details. From their advertising literature, it is clear that the W/WS repair

processes used by NORDAM and Perkins are consistent with the original manufacture of the W/WS. The repairs made by The Glass Doctor, on the other hand, because they involve injection of adhesives and resins into the W/WS, are different than the OEM processes.

Terms and conditions for a site visit and repair of a number of W/WS were successfully negotiated only with NORDAM and Perkins. Thus, only NORDAM and Perkins made W/WS repairs for this program.

The set of 75 C/KC-135 W/WS Battelle had to work with was divided, and half sent to NORDAM and half sent to Perkins. Each vendor evaluated the repairability of the W/WS that they were sent and provided an estimate of the repair costs for each W/WS. In conjunction with Battelle engineers, a subset of the 75 W/WS was selected for repair. Perkins repaired 7 #1 W/WS and 2 #4 W/WS. NORDAM repaired 8 #1's and 8 #4's.

Tables 3.1 and 3.2 provide details of the prototype repairs made to the #1 and #4 W/WS that were subsequently tested. To fill out the test matrix, unrepaired W/WS were included in the test program, one #1 and six #4's. The original intent was to have a balanced number of repairs from each vendor and a balance in the types of repairs made. Unfortunately, it did not work out this way, because Perkins got a disproportionately large number of unrepairable W/WS. Because the performance of unrepaired W/WS provides a baseline for as-removed condition, including them in the test matrix was essential.

4.0 PERFORMANCE TESTING

4.1 Test Philosophy

The fitness for purpose of the repaired C/KC-135 W/WS was evaluated using a rigorous test program. In formulating the test program, the plan was to select a set of tests that would assess the critical performance elements of the W/WS: general electrical/optical/mechanical characteristics, pressure integrity, residual strength, and impact resistance. Performing these types of tests at limiting load or operational conditions, failures would be encouraged in repaired W/WS that would not occur in new W/WS unless the repaired W/WS were degraded either by virtue of their age or by virtue of having undergone the repair process.

The test plan was developed as a joint effort between Battelle, OC-ALC, and the Flight Dynamics Laboratory at Wright-Patterson AFB. Because the Air Force does not own the Boeing 707 airframe design on which the C/KC-135 is based, they do not have W/WS drawings and the W/WS design specifications or W/WS vendor qualification test protocols. Consequently, the test plan was developed from the C/KC-135 Tech Orders and the open literature on W/WS testing.[1-10]

In order to assess whether the performance of the repaired W/WS is satisfactory, a standard for comparison must be defined. Obviously, the performance of new W/WS should be the basis for the comparison. Simply stated, the repaired W/WS should perform just like new W/WS. In an ideal situation, information for new W/WS would be available to define the required tests for the repaired W/WS and the existing new W/WS data would form the basis for the comparisons. The information available from Boeing and OC-ALC suggested that data on prior C/KC-135 W/WS testing was sparse or very difficult to retrieve, so the scope of the testing program had to include tests of new W/WS to generate the baseline new W/WS performance data. In addition, because of uncertainty in setting some of the parameter selections for the tests (load levels, primarily), the test program included a methodology phase verification to establish that the new W/WS would pass the tests. Although testing of new W/WS was primarily a response to the lack of readily available new W/WS test data, it does facilitate the process of making the comparisons because both new and repaired W/WS were tested under absolutely identical conditions.

The new W/WS used in this program were supplied by OC-ALC from stock at Tinker AFB. The new #1's were copilot side W/WS. All of the other W/WS in the program were from the pilot side. Copilot side #1 W/WS were used because the stock of these W/WS was higher. The pilot and copilot side W/WS are mirror images of one another, so they should perform identically.

The test program was originally to be conducted at OC-ALC or other Air Force test facilities, with Battelle providing oversight and test data analysis. After the test program was defined, an attempt was made to locate Air Force facilities to perform the prescribed tests. The test plan required facilities for general W/WS optical/electrical/mechanical inspection, pressure and thermal cycling, and bird impact testing. Although portions of the testing could be performed at various Air Force facilities, no single site had all of the capabilities, and in many cases, substantial modifications or upgrades would be required to accommodate the specific needs of this program at sites where portions of the work could be done. In addition, quoted costs at the Air Force facilities were quite high. To fulfill the testing requirement, therefore, an outside vendor, PPG Industries, Inc. Aircraft Products Division was subcontracted to do all of the C/KC-135 W/WS testing.

PPG's Aircraft Products Division, located in Huntsville, Alabama, has been in the aircraft transparency business since 1926 and is an OEM supplier for C/KC-135 W/WS as well as other Boeing 777 series aircraft. The Huntsville plant is America's largest and most modern facility for producing aircraft transparencies. It fabricates W/WS with heat strengthened and chemically tempered glasses, as-cast and stretched acrylics, and polycarbonates for commercial, military, and general aviation aircraft. As a leader in the field of aircraft transparency technology, PPG has built an impressive W/WS qualification testing facility. The facility includes bird impact testing, environmental testing, high strain rate material evaluation, dynamic deflection analysis with high speed photography, dynamic stress analysis with strain gages, and ballistic testing for transparent armor. In performing the tests for this program, PPG used the same test fixtures, test procedures, and QA

requirements in use today to make new OEM W/WS for C/KC-135's. These capabilities at a single site, coupled with their intimate knowledge of the C/KC-135 W/WS and the functionally equivalent Boeing 777 series products, proved valuable to this program.

4.2 Quality Assurance

The testing conducted at PPG was performed in accordance with specifications defined in contract deliverable Data Item A046 to OC-ALC entitled "Final Master Test Plan/Program Test Plan on Development of Repair Processes and Sources for C/KC-135 Aircraft Windows/Windshields." This document was submitted to PPG as "Program Test Plan on Testing of Repaired C/KC-135 Aircraft Windows/Windshields" for preparation of their proposal bid. The corresponding PPG document, "Verification Test Procedure on C/KC-135 Aircraft Repaired Transparencies #1, #4, and #5 Windows, Revision A," was reviewed and approved by Battelle and defined the detailed scope of work.

PPG is an OEM supplier for C/KC-135 W/WS and consequently, they have a vested interest in selling new W/WS. Because using repaired W/WS would reduce sales of new W/WS, PPG could be perceived as having an inherent bias against repaired W/WS which might be reflected in the test results. PPG offered, and Battelle frequently exercised, the option to witness the tests. No indication was ever detected that they were attempting to influence the outcome of the tests. Their work was always done to the highest of professional standards. Fixture fabrication, minor deviations from the prescribed test procedures to accommodate instrumentation problems, etc., were all done with Battelle's concurrence. Suggestions that Battelle made to enhance the value of the test program were willingly implemented. Their final report is presented as a factual record of their observations and does not attempt to bias the conclusions of this report.

All instrumentation used in the conduct of this program was calibrated in accordance with PPG Quality Control procedures which guarantees that all significant instrumentation was in calibration when used and that adequate records are kept to document such calibrations.

4.3 General Inspection

4.3.1 Test Procedures

General electrical/optical/mechanical testing of repaired W/WS was performed to ensure that the W/WS is in specification electrically, that the repair operations have not adversely affected optical qualities, and that the fit and finish is correct. All of the W/WS tested in this program were initially given a thorough 14-item inspection by the PPG Quality Control Department. The inspection included:

1) Locating and recording the customer part number

2) Locating and recording the W/WS serial number

3) General visual inspection

4) Gasket/seal evaluation

5) Thickness measurements at prescribed locations

6) Physical tolerance check

7) Bus-to-bus resistance

8) Sensing element resistance

9) Electrical insulation integrity test

10) Heater operation test

11) Heating film scratch test

12) Luminous transmittance and haze measurement

13) Optical deviation measurement

14) Optical distortion photograph.

With little exception, the indication of which W/WS were new, repaired, or unrepaired was difficult to determine from a superficial visual examination. Only a detailed technical examination, equivalent to an OEM post-production quality control check, was able to uncover differences between the W/WS.

4.3.1.1 General Visual Examination

A visual examination was performed on each W/WS to assess its general condition. During this inspection, the part number and serial number were located and recorded, the W/WS was checked for delaminations and vinyl cracks, and the condition of the seal was evaluated. Criteria for the various aspects of the visual examination were based on PPG experience as an OEM for these W/WS. A rating of accept or reject was employed.

4.3.1.2 W/WS Dimensional Measurements

The repair of delaminations involves re-autoclaving of the W/WS to rebond the vinyl inner layer to the glass. Because the vinyl layer is pressed at an elevated temperature and consequently may flow, the overall thickness of the W/WS may be reduced and the location of power/sensor terminals and bolt holes may shift. To determine if the repair processes cause such changes, some dimensional measurements of the W/WS were made.

To assess the extent of thickness reduction caused by re-autoclaving, total thickness of the W/WS was measured at selected locations. For the #1 W/WS, a 12-point grid was used, while a 2 by 2 grid was used for #4 W/WS. Measurements were made to the nearest 0.001 inch using a micrometer.

The physical tolerance check was made to see if critical dimensions, including proper fit dimensions, location of electrical connections, and bolt hole locations, had been changed by the repairs. Each W/WS was checked using check fixtures used in the original manufacture of these W/WS. An overall dimensional trim check was requested, but the OEM check tool was designed to be used prior to application of the edge coating material. Removal of the edge coating to make the measurements did not seem justified, in light of the fact that part of the repair process entails replacement of the edge coating, so the overall dimensional trim measurement was abandoned. A go-no go rating was used for the check fixture tests that could be made.

4.3.1.3 Basic Electrical Measurements

Electrical resistance measurements were made using the standard electrical resistance measurement function on Fluke digital multimeters to determine if the heaters and sensors were within acceptable tolerances. Both bus-to-bus resistance and sensor resistance (#1 W/WS only) were measured. From the Boeing overhaul manual, the bus-to-bus resistance should be 31-58 ohms for the #1 W/WS and 60-100 ohms for #4 W/WS. Sensor resistance for #1 W/WS is temperature dependent, and should be 305 to 320 ohms at 70° F. The #4 W/WS does not have an integral sensor.

Electrical insulation integrity was checked using a Hipotronics 300 Series Hipot and Megohmmeter at 2500 volts A.C. On #1 W/WS, insulation integrity was checked between the power bus and the sensor element, sensor element and the metal frame retainers, and from sensor element to sensor element. On #4 W/WS, the integrity was checked between the power bus and the metal frame retainers. Only a pass or fail rating is considered.

4.3.1.4 Heater Operation Tests

Sensor operation and heating uniformity were evaluated by infrared imaging. In this test, the W/WS was powered with 60 Hertz power at a voltage appropriate to the W/WS heater resistance. During the power up, the ability of the W/WS sensor to regulate the

temperature was established. When thermal equilibrium was attained, an infrared imaging system was used to make a photograph of the thermal contours on the glass.

To supplement the thermal imaging heater test, a scratch test of the heater film was performed. In this test, the heater is powered up (350 volts A.C. for #1 W/WS, 81 volts A.C. for #4 W/WS) and the W/WS is viewed using polarized light. Although the vinyl core ply of the W/WS is birefringent, scratches in the heater film show up dramatically as black-gray starbursts. A pass-fail rating on the scratch test is given.

4.3.1.5 Optical Performance

The optical performance of each W/WS was assessed in three ways; a haze and luminous transmittance test, an optical deviation measurement, and an optical distortion test.

Haze and luminous transmittance measurements were performed in accordance with ASTM D-1003-92, "Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics." The luminous transmittance test measures how transparent a body is, and is the ratio of the light transmitted through a body to the light incident upon it. The haze test measures the cloudy appearance of an otherwise transparent specimen caused by light scattered from within the specimen or from its surfaces. Haze and luminous transmittance measurements will detect whether the repair processes have adversely affected the clarity and/or coloring of the vinyl and whether the glass surfaces have been adequately polished. The haze and luminous transmittance measurements were made using a Pacific Scientific XL-211 Hazegard System hazemeter at the center of each W/WS. Per Mil-G-25871B (Military Specification: Glass, Monolithic, Aircraft Glazing) Paragraph 3.7, the original luminous transmittance should be greater than 72 percent and 78.4 percent for #1 and #4 W/WS, respectively. The original haze of a transparency greater than 0.62 inches thick should be less than 2.5 percent, per Mil-G-25871B Paragraph 3.9.

Optical deviation measures the flatness of a transparency. In the case of a repaired W/WS, grinding, polishing, and/or uneven pressing to remove delaminations may cause the front and back surfaces of the W/WS to deviate from a parallel condition, causing images to be deformed. PPG's "German Light," measures the flatness of a transparency using the distance between the front surface reflection of a normally directed beam of light and the light reflected from the back surface of the transparency to calculate the angular deviation from parallel. Measurements are given in terms of minutes of angular arc.

Optical deviation was measured using MIL-G-25871B Paragraph 4.4.6.2.1 as a reference at 8 locations on #1 W/WS and at 4 locations on #4 W/WS. The measurement locations were principally around the edges of the W/WS where deviation is expected to be most severe in a relaminated W/WS. Deviations under 4.5 arc minutes are considered acceptable anywhere 2 inches in from the forward edge, top and inboard edges and 4 inches in from the aft edge on #1 W/WS. Deviations of up to 9 arc minutes are acceptable in the

#1 W/WS edges. Deviation for the #4 W/WS is much less stringent than for #1 W/WS, 18 arc minutes anywhere 2 inches in from the edges.

Optical distortion was assessed using MIL-G-25871B Paragraph 4.4.6.3 as a reference. The distortion was determined by a single-exposure photograph of a grid viewed through the W/WS. Photographs were made with the W/WS parallel to the grid board. There is no reference specification for distortion for these W/WS. A distortion of greater than 1 part in 40 is essentially no distortion. As a reference, MIL-W-81752A sets a distortion limit of 1:15 for Navy fighter/attack aircraft. A 1 part in 4 distortion would probably be considered unacceptable for the #4 C/KC-135 W/WS.

4.3.2 General Inspection Test Results

Tables 4.1 through 4.8 summarize the results of the general inspections. In a number of areas, the repaired W/WS are the equivalent of new W/WS - dimensional fit, optical properties, and heater operation. There are, however, some troublesome areas - seals, unremoved delaminations, some insulation integrity faults, and a few out of specification heater resistances that suggest that the repaired W/WS are not quite up to OEM standards for a new W/WS. As indicated, most of the general inspection tests had an accept/reject criterion. For the heater tests and optical distortion, there are no established criteria. Figures 4.1 and 4.2 show thermal images from the heater tests. Figures 4.3 and 4.4 show the worst optical distortion found during the inspections. Appendix B contains the data sheets for the general inspections.

In addition to the general inspection data summarized in the tables and figures, two interesting items worth noting came to light. First, there was one commercial fleet W/WS in the program, and second, the new #1 W/WS were surprisingly old.

One of the #1 W/WS, S/N 83-H-11-7-432, has a commercial part number, 5-89354-3096, instead of the expected military part number 5-89354-501 (pilot side #1). Superficially, the two W/WS look identical and can be interchanged. The commercial #1 W/WS, however, unlike the military #1 W/WS, does not have slip planes and edge heaters. Rather, the slip planes and edge heaters of the military #1 W/WS have been replaced by a PPG-proprietary urethane ply. From the discussion in Section 2.1 about the construction of the C/KC-135 W/WS, the slip planes are areas around the edge of the W/WS where the glass has been prevented from bonding to the vinyl so that the edge of the glass does not become overstressed during thermal expansion. The urethane ply in the commercial W/WS accommodates the differential thermal expansion with a fully bonded W/WS structure. The edge heaters keep the vinyl "soft" in the W/WS corners. According to PPG, the urethane layer in the commercial W/WS reduces the tendency for delamination and edge chipping, and does not degrade any of the other properties of the W/WS. PPG feels that the commercial W/WS is superior to the military counterpart.

The new #1 W/WS were manufactured in 1986. This suggests that either the W/WS inventory at Tinker AFB is not maintained on a first-in first-out basis, or that reorder

quantities are large and that it takes a long time to deplete the stock. In any event, because of the potential time lag between manufacture and installation, manufacture date is not a good indicator of possible service life. Some of the new #1 W/WS were made several years before some of the W/WS that were repaired, and so it is not appropriate to assume that W/WS with older serial numbers have seen more service. Whether or not this is common to all of the W/WS in the inventory is not known, but it is something to consider if a service life limitation is imposed that does not track actual use.

4.4 Pressure Integrity

4.4.1 Test Procedures

Pressure integrity was evaluated with a three-step sequence. The first step was a proof pressure test. Samples which passed the proof pressure test then went on to a cyclic pressure durability test. Finally, samples which passed the cyclic durability test were proof pressure tested again.

4.4.1.1 Proof Pressure Test

This test was performed as an initial acceptance and final test on all pressure integrity test articles. The test candidates were mounted in a test fixture and pressurized at a rate not exceeding 0.84 psi per minute to 1.33 times the C/KC-135 relief valve setting of 9.42 psi (12.59 psig). The maximum pressure was held for 15 minutes and then released at a rate not greater than 0.84 psi per minute. The test was conducted at ambient temperature. At completion of the test, the W/WS was inspected for delamination and electrical resistance.

The data requirements for the proof pressure test consisted of pressure-time records and the post-test delamination inspection and electrical resistance measurements. For test articles that did not hold pressure due to breakage or cracking, a photograph of the failed W/WS was required.

The criterion for failure of the test was inability to hold pressure due to cracking or breakage. Delamination or failure of the heater to operate were to be noted, but were not sufficient to disqualify the specimen from further testing.

4.4.1.2 Cyclic Durability Test

This test was performed on all W/WS that passed the initial proof pressure test. The test was conducted with an outward-acting constant amplitude cyclic pressure varying from 0.00 to 9.42 psig, applied at a rate not greater than 0.84 psi per minute. The inboard side of the W/WS was to be held at room temperature (72° F ± 10° F) and the outboard side was to be at -65° F ± 10° F with the heater energized. The cyclic pressure was to be applied until failure was observed or run out, with run out calculated to simulate a 10 year life for a

C/KC-135 (520 cycles). Test article inspections were to be performed at 5 years of simulated service and at the conclusion of the test.

The data requirements for the cyclic durability test consisted of pressure, inboard side air temperature, outboard side air temperature, and bus-to-bus resistance, all as a function of time. Marking of delaminations on the surface of the outer ply and then photographing the W/WS served to document any visual damage to the W/WS. Mode of failure and a photograph of the failed test article were to be used to document specimens that did not survive this test.

The criterion for failure in the cyclic durability test was inability to hold pressure due to cracking or breakage. Failure of the heater was to be noted, but was not sufficient cause to stop the pressure cycling.

4.4.2 Test Facility

The test facility for conducting the pressure integrity testing utilized PPG's Environmental Qualification Test Facility. This facility has three walk-in environmentally controlled chambers that can be used to expose transparencies to temperatures as low as -100° F and as high as +185° F. Pressure chambers with mounting flanges for transparencies fit into the wall of the environmental chambers to permit simultaneous pressure and temperature control, per Figure 4.5. Internal heating and cooling capacity, as well as small fans inside the pressure chambers ensure that the transparency inboard side conditions can be maintained, independent of the outboard side conditions. The facility is controlled by 16-bit Macsym 350 process control computers that manage the temperature and pressure in real time, and perform data acquisition.

Each W/WS was instrumented with 4 thermocouples, two inboard and two outboard, one directly on the glass surface and one 1-inch off the surface. A strain-gage-based pressure transducer was used to measure the pressure chamber pressure.

The #1 W/WS heaters were powered by a 400 Hertz 0-500 volt A.C. motor-generator set adjusted to generate an output voltage consistent with the W/WS bus-to-bus resistance. On the #1 W/WS, the integral sensor was used to control the temperature. The #4 W/WS were powered by 70 volts A.C. 60 Hertz power derived from 120 volt A.C. building power. This voltage is consistent with T.O. 1C-135(K)A-2-2 Paragraph 8-9. The temperature of the #4 W/WS was controlled using a thermocouple-based temperature controller set to have the same operating characteristics as the thermal snap switch that is found on C/KC-135's per T.O. 1C-135(K)A-2-2 Paragraph 8-10: control point about 100° F, switch closure at 90° ±10° F, switch opening at 110° ± 10° F.

The pressure integrity test W/WS were mounted in simulated frames per the drawings shown in Figures 4.6 and 4.7. The rationale for using simulated frames was; 1) less expensive than using an actual fuselage section, and 2) a simulated frame could be made

much stiffer than the sheet metal fuselage section and thus would maximize potentially damaging deformation in the W/WS.

The #1 W/WS were bolted to the frame shown in Figure 4.6 using hardware equivalent to that used in the actual aircraft W/WS installation kit, per Figure 4.8a. Unlike the actual aircraft installation, Grade 8 socket head cap screws and nuts were used. Aluminum washers similar to the ones in the installation kit were used. No curtain clips or wire clamps were installed. Bolt torques and tightening sequences followed T.O. 1C-135(K)A-2-2 Paragraph 8-55. One #1 W/WS was tested at a time. Figure 4.9 shows a #1 W/WS in the pressure test facility.

The #4 W/WS were installed using 16-gauge sheet metal retainers and silicone rubber gasket strips fabricated to simulate those used in the aircraft, Figure 4.8b. Grade 8 socket head caps screws and nuts were used instead of actual aircraft bolts and nuts, with no curtain clips or wire clamps. Bolt torques and tightening sequences followed the prescriptions in T.O. 1C-135(K)A-2-2 Paragraph 8-61. Two #4 W/WS were pressure tested at a time, as shown in Figure 4.10.

4.4.3 Test Results

The results of the pressure integrity testing are presented in Tables 4.9 and 4.10. None of the W/WS, repaired, not repaired, or new, exhibited any catastrophic failures. Two of the repaired W/WS did experience delaminations, while no evidence of delamination was detected in the new W/WS. Figure 4.11 shows the worst delamination observed in a #1 W/WS. Figure 4.12 shows the worst delamination observed in a #4 W/WS. In these figures, the edge of the delamination has been outlined with a black marker. The delamination in the #1 W/WS would not interfere with pilot vision, and may not even be noticed. The delamination in the #4 W/WS, would, most likely, be noticed and reported by a pilot.

A curious "healing" phenomenon was noted in some of the W/WS. Immediately after the pressure cycling, the W/WS were examined for delamination and a marker was used to outline its edge. Some time later, after the W/WS had returned to room temperature, the extent of the delamination was observed to have reduced. Residual stresses in the W/WS cause the delaminations to close up. Discussing this point with the PPG staff confirmed that the "healing" phenomenon is not unique to our tests. PPG indicated that they occasionally get W/WS back on warranty that do not appear to be damaged in any way. Applying some thermal and pressure cycles to the W/WS is generally sufficient to open the delaminations. Although the consequences of this phenomenon for this program are nil, it does suggest that a pilot or copilot could report diminished vision in a W/WS that may not be detectable by the ground crew.

4.5 Residual Strength Assessment

4.5.1 Test Procedures

The residual strength of a selected subset of the W/WS that passed the pressure integrity tests was assessed with a falling ball impact test. In this test, a spherical steel ball was dropped onto the W/WS using Mil-G-25871B Paragraph 4.4.3 as a reference, see Figure 4.13. Unlike Mil-G-25871B where the purpose is to make certain that no separation or delamination of glass from the vinyl occurs, the purpose of this test was to see if repaired W/WS that have been pressure cycled have a reduced capacity for moderate impacts.

The procedure for conducting the falling ball impact tests was to establish a suitable ball weight and drop height to cause significant outboard ply damage without breaking the core ply of a new W/WS that had passed the pressure integrity tests, and then test a few of the remaining W/WS under these conditions.

In the case of the #1 W/WS, a 2-pound ball dropped from a height of 15 feet broke the outer glass ply and crushed the glass in the impact area with a web of cracks emanating from the impact site. Because of the size of the #1 W/WS, two ball drops could be performed, in some cases. For the #4 W/WS, a 1-pound ball dropped from 15 feet did similar damage. A single drop was done on #4 W/WS.

4.5.2 Test Facility

The test facility for conducting the ball drop consisted of a drop tower with ball guide tube and electromagnetic ball release mechanism, and a support frame for the W/WS. Because the PPG ball drop facility was designed only to accommodate small test panels and not full W/WS, boundary conditions at the W/WS edges could not be freely prescribed and a center drop on the #1 W/WS could not be done. Rather, the W/WS were supported by a square frame with a 1-foot by 1-foot opening on the face of the bottom (inboard) glass ply. Due to a space restriction, approximately half of the #1 W/WS extended beyond the support frame, but was supported at the same height as the impact target area. Because all W/WS were treated consistently, the somewhat imprecise nature of the boundary is not as issue.

4.5.3 Test Results

Tables 4.11 and 4.12 detail the results of the falling ball residual strength impact testing, while Figures 4.14 through 4.19 show the test set-ups and selected consequences of the impacts. The results of the ball drop are not conclusive because only a single new W/WS was tested of each type. The worst damage occurred in repaired W/WS with delamination, so there appears to be a suggestion that the ball drops do more damage to the repaired W/WS than the new W/WS.

4.6 Bird Impact Testing

4.6.1 Test Procedures

The bird impact testing was conducted using ASTM F330-89, "Bird Impact Testing of Aerospace Transparent Enclosures" as a model. The W/WS were mounted in a simulated frame placed at the correct inclination and sweepback angles for level flight and impacted with a real 4-pound bird in the center at 250 knots. Testing was done at room temperature, performing a single shot on each W/WS. A spall sheet was placed behind the W/WS.

The simulated frames used in the bird impact tests were similar to the ones used in the pressure integrity tests, Figures 4.20 and 4.21. The rationale for using simulated frames was the same as in the case of the pressure integrity tests. Mounting hardware and installation procedures were consistent with the applicable C/KC-135 Tech Order, T.O. 1C-135(K)A-2-2. Figure 4.22 shows the bolts, O-rings, washers, and nuts used to secure a #1 W/WS in the test frame.

The #1 W/WS were inclined 45 degrees with a sweepback angle of 30 degrees, while the #4 W/WS were inclined 58.12 degrees with a sweepback angle of 35.3 degrees, per information obtained from Boeing and verified by measurement on a C/KC-135 by OC-ALC. The reference for the inclination angle is a vertical line. The reference for the sweepback angle is a horizontal line normal to the centerline of the aircraft. The #1 W/WS as installed presents a fairly large target for the bird package. Because of the size and oblique installed angle, the bird package nearly fills the #4 W/WS.

The data requirements for the bird impacts tests consisted of a pre-test photograph, bird weight, high speed film of the impact, impact velocity, a post-test photograph, a record of the disposition of the spall sheet, and written comments from a post-test examination of the W/WS.

4.6.2 Test Facility

PPG's bird impact test facility is one of the most advanced in the world, capable of shooting one to eight pound birds at impact velocities from 29 to 751 knots, depending on the bird weight. The pneumatic cannon has a 40-foot long barrel with a nominal 10-inch diameter. A pressurized reservoir provides compressed air to propel a metal can, called a sabot, containing the bird to the target. When the sabot reaches the end of the barrel after firing, it is collected by a stripper and spring system that absorbs the sabot's kinetic energy. As the bird continues to the target, approximately 10 feet away, it passes through a timing trap system to measure its velocity. Figure 4.23 shows a schematic of the important elements of the bird cannon.

The velocity of the bird at impact is a calibrated function of the air pressure pushing the sabot down the barrel. A dual rupture diaphragm system fires the gun. Assuming that

Diaphragms 1 and 2 in Figure 4.23 are rated to burst at P_b psi and that test pressure, P_t, is greater than P_b but less than $2P_b$, putting $\frac{1}{2}P_t$ in the Step Chamber keeps both diaphragms from bursting. Opening the Solenoid Exhaust Valve vents the Step Chamber to atmosphere and causes Diaphragms 1 and 2 to burst almost simultaneously applying test pressure in the reservoir to the sabot.

A massive frame support system, adjustable for inclination angles from 25 to 85 degrees was use to hold the simulated W/WS frame. Figure 4.24 shows the support frame with a #1 W/WS mounted. Figures 4.25 and 4.26 show views of W/WS mounted and ready for testing. To ensure that the test article is in its proper position, the impact point is identified with a helium/neon laser centered in the end of the barrel. Installation angles were measured with a precision clinometer.

High speed photographic records of the impacts were made with up to three 16-millimeter cameras operating at up to 11,000 frames per second. The cameras and lighting system are tied into the cannon firing system so that when the fire button is depressed, the lighting is switched on, the cameras come up to speed, and an internal camera speed signal fires the gun. Typically, two cameras recorded the impact from the front, while the third camera recorded the impact from the rear.

Bird speed is measured in three axes and averaged to compensate for minor deviations in the bird package's flight pattern prior to impact. Basically, the time for the bird package to traverse a fixed distance is measured and converted to velocity. Because the timing system requires more than 50-percent of the timing system lights to be obscured, false time readings and consequent incorrect speed indications triggered by small particles or moisture clouds that precede the bird package are eliminated. Figure 4.27 shows the velocity timing trap and front camera positioning.

A spall sheet was placed at the pilot's head position to determine if any glass fragments or bird residue comes through the W/WS in the event of a failure. In Figure 4.25, the spall sheet can be seen behind the W/WS as a black rectangular sheet slightly left of center. Figure 4.28 shows the spall sheet from behind a #1 W/WS.

4.6.3 Test Results

A summary of the bird impact test results is presented in Tables 4.13 and 4.14. A gradation in impact damage for #1 W/WS is shown in Figures 4.29 to Figure 4.34, ranging from no damage to all glass plies failed. A similar gradation of bird impact results for #4 W/WS is shown in Figures 4.35 to 4.40. Other W/WS with similar damage look about the same as these figures. The bird impact data sheets are attached as Appendix C.

Concerning the test comments about bird residue on the spall sheet, it must be noted that the simulated frame had no aerosmoother sealant between the frame and the transparency. Furthermore, there was no cosmetic trim pieces on the inside of the W/WS.

Either one or both of these would probably have prevented bird residue from squeezing between the W/WS and the frame. Ply breakage would not be affected by the presence of aerosmoother or trim pieces.

4.7 Performance Testing Summary

The performance testing data have been summarized in Tables 4.15 to 4.18. From these summaries, the obvious conclusion is that used W/WS do not perform as well as new W/WS. Although trends are difficult to identify in the data because there always seem to be exceptions and because the data base is so small, the performance of W/WS that have been in service, whether repaired or not, is below that of new W/WS.

In a number of categories, the repaired W/WS were the equal of new W/WS: dimensional fit, optical properties, and heater performance. In other cases, they were not: residual delamination, seals and bumpers, delamination during pressure cycling, more damage in the ball drop test, and poorer performance in the bird impact testing. Some of the issues such as seal and bumper problems and residual delamination can easily be rectified. The delamination during pressure cycling is merely annoying because it is an impaired vision issue that would develop over time and is not a serious structural failure.

The bird impact test results are conclusive. The new W/WS performed significantly better than the repaired and not repaired W/WS. At worst, the outboard ply of a new W/WS was broken. For the repaired #1 W/WS, fully half of the samples had all three plies fail, although none had bird penetrations. For the repaired #4 W/WS, only an outboard ply was broken. The unrepaired #4 W/WS performed the worst in the bird impact tests, with one whole W/WS punching out of the frame. This W/WS was rejected for repair, but it appears that it was for an out-of-specification heater and not for any unrepairable structural deficiency. Similarly, the other two unrepaired #4 W/WS that were damaged were also rejected for out-of-specification heaters. The fact that repaired W/WS performed somewhat better than unrepaired W/WS seems to indicate that the repairs themselves do not degrade the W/WS.

Some of the repaired #1 W/WS had a reduced thickness in the edge attachment area. The reduced mounting edge thickness was noticed when bolts that had previously worked satisfactorily for mounting new W/WS in the frames for bird impact tests appeared to be too long. Basically, the bolts would bottom-out on the aluminum spacers in the phenolic mounting block before the W/WS was tight to the frame (see Figure 2.4). The reduction in frame thickness could have been caused by extrusion of the vinyl inner layer during the relamination repair process, it could have occurred as a result of creep during service, or it could be an artifact of the original manufacturing processes. Table 4.19 summarizes edge measurements that were made on the #1 bird impact W/WS and a set of unrepaired W/WS that were not part of the rest of this program. Reduced mounting edge thickness appears to correlate with more severe impact damage, but does not correlate with age or whether or not the W/WS has been repaired.

5.0 COST ANALYSIS

The second element in the evaluation of the feasibility of using repaired W/WS in Air Force fleet aircraft was a cost analysis. The commercial fleet has a very favorable cost benefit using repaired W/WS. If using W/WS is to be a viable option for the Air Force, the costs for making the repairs has to be justifiably less than the cost of a new W/WS.

5.1 Repair Costs

During initial contacts with NORDAM, Perkins, and The Glass Doctor and prior to contracting for any repairs, an estimate was solicited for repairing small numbers of each of the five C/KC-135 W/WS types. NORDAM prices their repairs on the basis of how much work is required to do the repair, i.e., a W/WS that only needs polishing costs less than a W/WS that needs polishing and relaminating, and thus they could only give rough estimates. Perkins has a fixed price for repairing a given type of W/WS, regardless of the number of steps required to repair the W/WS, and offers up to a 30-percent discount for large volume customers. The Glass Doctor offered a fixed cost per W/WS type. All of the repair vendors perform incoming inspections and reject unserviceable W/WS, charging only for those that they successfully repair. Table 5.1 summarizes the initial repair quotations from the three vendors.

The actual costs for making the prototype repairs on the #1 and #4 W/WS that were performance tested are listed in Tables 5.2 and 5.3. Actual costs were consistent with the initial repair estimates. For reference, Table 5.4 summarizes the quoted repair cost for all 75 of the C/KC-135 repair candidate W/WS that were procured for this program. The latter table reflects the incoming W/WS inspections performed by NORDAM and Perkins.

5.2 Costs of New W/WS

OC-ALC provided costs for new C/KC-135 W/WS. The data in Table 5.5 is the Air Force purchase price as of January 1994.

5.3 Cost Comparison

The average cost for making the prototype repairs on the C/KC-135 #1 W/WS was $1,943, while the average cost of making the prototype repairs on the #4 W/WS was $899. Comparing these numbers to the current purchase price, the repairs cost 75-percent of the purchase price of a new #1 and 65-percent of the purchase price of a new #4.

Taking the extremes of the initial repair estimates, actual repair costs, or cost quotes from NORDAM and Perkins, and assuming a large enough volume so that Perkins would offer a 20-percent volume discount, the best-case, actual, and worst-case cost scenarios for repaired C/KC-135 W/WS are as shown in Table 5.6. Had The Glass Doctor participated in the program and repaired W/WS at the prices in their estimate, the low values in Table 5.6

would have gone to 51-percent for #1 W/WS, 62-percent for #2 W/WS, and 34-percent for #3 W/WS.

6.0 CONCLUSIONS, RECOMMENDATIONS, AND DISCUSSION

6.1 Conclusions

The Air Force, in an effort to reduce fleet maintenance costs, is considering the possibility of using repaired W/WS. Prior to adopting such an operating policy, however, the Air Force decided that a systematic evaluation was required to ensure that repaired W/WS are safe and that they provide a reasonable cost savings benefit. Based on the reported cost savings and favorable experience that the commercial fleet has had with repaired W/WS, the use of repaired W/WS seems very attractive.

The approach followed for evaluating whether the use of repaired W/WS is a viable option for the Air Force was to procure some used W/WS, make repairs on them, and then subject the repaired W/WS to a series of tests to determine the difference in performance when compared with new W/WS. The cost to make the repairs provides the data for the cost benefit analysis. The test results provide the data for an evaluation of fitness for purpose of the repaired W/WS.

The test results indicate that repaired W/WS are not equal to new W/WS. Many of the repaired W/WS still contain defects that would not pass an OEM quality assurance inspection. None of the W/WS, new, repaired, or not repaired, exhibited any dramatic differences in pressure integrity. Some delamination occurred in two of the repaired W/WS during pressure cycling, but it was not severe. The residual strength of the pressure cycled W/WS tends to suggest that the repaired W/WS are not quite as good as new W/WS. The bird impact test results are quite clear - the new W/WS outperform either repaired or unrepaired W/WS.

Having established that repaired W/WS are not equal to new W/WS, the question that remains to be answered is whether or not repaired W/WS are "good enough." The replacement criteria in the C/KC-135 W/WS Technical Order, T.O. 1C-135(K)A-2-2, are founded on two major principles:

1) A W/WS that has any condition that impairs visibility must be replaced

2) The W/WS heater must function properly.

A number of specific inspection items, subordinate to these principles, provide additional criterion for W/WS replacement. According to the prevailing Tech Order inspection criteria, none of the repaired W/WS would have been removed for cause from service. The fact that they were removed and were subsequently restored to a condition better than the W/WS

replacement criterion suggests that they were in fact "good enough." The repair vendors do not claim that they can restore a W/WS to a brand new condition. Rather, they indicate that the repairs they perform return the W/WS to a fully acceptable and functional condition. Under this philosophy, the repaired W/WS do appear to be "good enough."

In terms of performance, the most demanding test is the bird impact. Using the criteria set forth in MIL-W-81752A (Windshield Systems, Fixed Wing Aircraft General Specifications For), Paragraph 3.7.2 specifies that the W/WS should be able to sustain a 4-pound bird impact at maximum achievable operational true airspeed in level flight at up to 5000 feet altitude without any spall. This is substantially the same requirement for commercial fleet W/WS set forth in "Part 25 - Airworthiness Standards: Transport Category Airplanes" of the U.S. Federal Aviation Regulations, Paragraph 25.775. The velocity prescription dictated by MIL-W-81752A and FAA 25.775 is operationally restricted, however, by Part 91, Paragraph 91.117 of the FAA Federal Aviation Regulations which states that 250 knots is the maximum allowable aircraft speed below 10,000 feet above mean sea level without special authorization. Assuming that the 250 knot impact velocity is the proper performance criterion, all of the new and repaired #1 and #4 W/WS meet the no bird penetration requirement, while two of the repaired #1 W/WS technically fail the no spall criterion. From a practical viewpoint, the spall was very modest, so the repaired W/WS appear to be "good enough."

The lone W/WS that experienced a catastrophic bird impact failure (#4 W/WS, S/N 7-H-2-4-35) was not repaired. Reviewing the repair vendor's report on the W/WS, it was rejected for repair due to a heater that was out of specification and not for any gross structural deficiency, such a vinyl cracking or delamination. The only other vendor-reported damage was scratches. The Air Force HOWMAL (how malfunctioned) comments on the removal tag indicated that it had a burnt discoloration in the corner at the edge of the heater. The fact that the heater was defective suggests that the W/WS may have been subjected to in-service pressure cycles with the vinyl unheated. This would have been hard on the glass-vinyl interface, because the vinyl would have been relatively brittle, predisposing the W/WS to fail in the bird impact test. On the other hand, if the heater had been satisfactory, the W/WS probably would have been polished and considered repaired. Because the vinyl itself failed, it is unlikely that polishing would have changed the outcome of the test.

The bird impacts done for this program represent the first ever C/KC-135 W/WS bird impact tests. In addition to demonstrating that repaired W/WS are probably "good enough," the work in this program has confirmed that the basic C/KC-135 W/WS design is adequate.

The new #1 W/WS used in this program were manufactured in 1986. The fact that they performed well in all of the tests, in spite of sitting in warehouse storage for 7 years, indicates that these W/WS do not degrade in storage. This is quite important when considered in the context of a possible blanket 10-year replacement policy, because the only method available now to track the 10 years is by manufacture date. To implement a

meaningful 10-year W/WS replacement cycle policy, it would be necessary to track individual W/WS service history.

The cost analysis indicates that savings may be realized. For this program, the cost of making the repairs was 75-percent of the new W/WS purchase price for #1 W/WS and 65-percent for the #4 W/WS. Considering all five of the C/KC-135 W/WS types and the full range of estimates, quotes, and actual costs, repairing a W/WS might cost as little as 41-percent of a new W/WS, but it could also cost as much as ~~1~~32-percent. higher than a new W/WS.

The costs quoted are only the direct repair costs. To this must be added the direct cost of transportation and the indirect costs of procuring the service (contracting - more vendors will be involved), administrating ~~it~~ the service (accounts payable, records management, QA inspection of the vendors, etc.) and operating ~~it~~ the service (storage, shipping and handling, outgoing/incoming inspection, etc.). These items will certainly make the economics less favorable and to ignore them would be a false economy. On the positive side of the economic issue, the repair vendors do not directly charge for W/WS inspections or for any repair work that does not result in a shippable W/WS. The cost, both economic and environmental, of disposal of all of the W/WS that are currently removed and sent to a landfill cannot be ignored. Repaired W/WS would certainly have an advantage here.

A final consideration of an economic nature that must be factored into the decision to use repaired W/WS is new W/WS availability. There may be a persuasive economic reason to use repaired W/WS if new W/WS are in short supply. The repair vendors could probably be queued up to make repairs, basically on demand, and could provide a "just in time" service. As opposed to having aircraft out of service because new W/WS were not available, repaired W/WS could be used.

6.2 Recommendations

Recommendations that can be made as a result of the work performed on this program are contingent upon the Air Force making a decision, based on the available data, that the performance of repaired W/WS is acceptable.

If, in the opinion of the Air Force, the performance of repaired W/WS is deemed "good enough:"

1) NORDAM Transparency Division, and Perkins Aircraft Services, Inc. are recommended as vendors. No recommendation can be made regarding The Glass Doctor, because they supplied no test articles for this program.

2) Based on the results of this study, the repair processes that can be recommended are:

    a) Relaminating using autoclave processes involving application of heat and pressure
    b) Grinding and polishing of the external surfaces of the glass
    c) Seal/bumper maintenance
    d) Minor clean-up of electrical terminals

3) Repair processes that cannot be recommended at this time by virtue of not having been used in this program are:

    a) Complete replacement of a glass ply
    b) Delamination or crack repair involving injection of adhesives or filling with transparent polymerizable resins
    c) Sensor replacement
    d) Busbar/heater wire repair/replacement

4) A formal Air Force quality assurance (Q/A) program should be instituted to set forth requirements for the repair vendors. This will eliminate the annoying, but easily corrected, problems with wrong seals/bumpers on repaired W/WS. In addition, this Q/A program should also be charged with performing an incoming inspection of W/WS coming back from the repair vendors.

5) A policy that prevents a W/WS from undergoing more than one repair cycle should be instituted. The contractual requirements for the repair vendors should stipulate that all repaired W/WS must be marked to identify that they have been repaired and by whom. No data have been collected to support the use of re-repaired W/WS.

6) The Air Force should use the cost data in this report as the starting point for a complete cost/benefit analysis to satisfy themselves that there is an economic advantage to using repaired W/WS. Full costs, including all direct and indirect cost for labor, materials, and facilities must be included. This must be done on a W/WS by W/WS basis, because the data from this program suggest that some W/WS can be replaced at less cost than they can be repaired.

It is important to emphasize that all of the recommendations offered above are contingent on the Air Force deciding that the performance of the repaired W/WS is adequate.

6.3 Discussion

In reviewing the test data, the question of why one W/WS should perform better or worse than another in a structural test was considered. Four possible causes were identified:

- Vinyl degradation - Vinyl, being a plastic is subject to UV degradation and general aging due to loss of plasticizer. As a result of the aging, the vinyl may become brittle and crack, thus reducing its load carrying capacity in the laminate. The vinyl could also be preferentially squeezed from the edge of the W/WS during a relaminating repair process or in service. Because the vinyl is the only structural ply that carries the load into the W/WS frame for a bird impact, if this occurred, the load capacity of the W/WS would be degraded.

- Grinding/polishing of the glass - The C/KC-135 W/WS use heat-strengthened glass. In producing this type of glass, the ply is heated to near its softening point and then quenched to introduce compressive residual stresses in the surface layers as shown in Figure 6.1. Tensile stresses inside the glass exist to equilibrate the compressive surface stresses. Because glass only fails due to tensile stresses at the surface, the residual compressive stresses must be overcome to initiate a failure. Grinding and polishing remove some of the beneficial compressive stresses, and hence, the overall strength of the glass ply is reduced. Removal of the highest compressive stress layer, however, must be balanced against removal of flaws. In concert with the obvious effect of removal of the highest compressive stress layer, as far as flaw tolerance goes, the surface may also not be as smooth after grinding/polishing. Smoother surfaces have less flaws and a profoundly higher strength[11].

- Stress corrosion cracking of the glass - The surface of glass contains many microscopic cracks and fissures, and under a sustained load, the presence of moisture exacerbates the growth of these cracks[12-15]. Generally, water vapor in the air is sufficient to cause the degradation. Elevated temperatures and longer exposures accelerate the stress corrosion cracking effect. Although there is no direct evidence that aircraft W/WS degrade dramatically from this phenomenon, the fact that the W/WS are highly stressed due to thermal and pressure loading, they are exposed to atmospheric moisture, they are routinely heated in a high stress state, and that old W/WS performed below new W/WS in the structural tests suggests that there may be more than a casual cause-effect relationship.

- Fatigue - Glass exhibits a complex load rate-cyclic loading behavior. Under a constant maximum load, no effect of cyclic loading is observed, but under increasing maximum load, cyclic loading reduces the strength[16,17]. The net effect for a W/WS undergoing repeated pressure cycles is not clear, but it seems plausible that some amount of micro-crack propagation occurs.

There is no conclusive evidence that the results of this test program can be directly attributed to any of the mechanisms described above. However, it does not seem unreasonable to suggest that they might. As far as the implications for use of repaired W/WS, vinyl degradation, stress corrosion cracking, and fatigue affect both repaired and unrepaired W/WS. Only repaired W/WS would seem to be susceptible to the grinding/polishing degradation mechanism.

It would be nice to be able to make generalizations about some W/WS being better repair candidates than others, possibly based on age. Unfortunately, there is just too little data to support such generalizations. There are enough inconsistencies in the data, i.e., new W/WS older than some of the repaired ones, some very old W/WS performing just as well as new W/WS (1971 manufacture #1 W/WS S/N 1-H-10-5-480 pressure cycle and ball drop, 1974 manufacture #4 W/WS S/N 4-H-10-9-69 bird strike), etc., that one cannot readily see trends in the data. To try to treat the test results in a statistical manner, looking for correlations, just does not make any sense with such small sample populations. The best that one can say is that repaired W/WS are not equivalent to new W/WS.

It is unfortunate that The Glass Doctor declined to participate in this program. The repairs that The Glass Doctor makes are unique, and based on their cost estimates, quite inexpensive. The long-term performance of the materials that The Glass Doctor injects into the W/WS may be a concern, particularly in terms of extended exposure to ultra-violet radiation. The quality assurance aspect of not being certain of what is being injected in any given repair is also of concern. On the other hand, The Glass Doctor does warranty repairs, other than improper handling, for up to three years.

The issue of commercial construction W/WS versus military construction W/WS deserves some comment. According to PPG, back when Boeing 707's were first coming into service, chipping of the outer ply glass in the corners was common and was attributed to uneven W/WS heating causing differential thermal expansion/contraction of the glass and the underlying vinyl. The slip planes in the current C/KC-135 W/WS are there to help control this problem. To completely eliminate the problem, Boeing tried sewing fine wires in with the vinyl, so-called edge heaters, to keep the vinyl "soft" in the W/WS corners. This was not very successful, because no additional power was applied to the W/WS and failure of the edge heaters was common. A second solution, was to put external glue-on edge heaters on the inside of the W/WS. This approach, unfortunately, does not put the heat where it is needed - at the outer glass ply to vinyl interface. The final solution, which is the current commercial W/WS standard, was to put a thin layer of polyurethane between the vinyl and the outer glass ply. Because the polyurethane is more ductile and does not bond as tightly to the glass as vinyl, the glass and vinyl can move somewhat independently. The polyurethane layer, which could simply be added to the existing W/WS because of the large tolerances on glass and overall assembly thickness, eliminated the edge cracking problems and did away with the need for slip planes and edge heaters. The cost of a polyurethane layer W/WS is something less than 10-percent higher than the cost of a vinyl-only W/WS. The polyurethane is itself significantly more expensive, but this is balanced against less labor because the slip

planes and edge heaters are eliminated. For commercial fleets, the higher cost is justified on the basis of more flight hours between W/WS replacements. For C/KC-135's, because they do not see nearly the flight hours per year that commercial planes see, the cost to benefit ratio for the technically superior polyurethane layer W/WS may not be low enough.

7.0 REFERENCES

1) MIL-W-81752A, "Windshield Systems, Fixed Wing Aircraft General Specification For."

2) Kelley, M.E., "Aircraft Transparency Testing Methodology," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

3) Bain, P.H., "An Industry Test Program for Interlayer Equivalency," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

4) King, R.D., and Wright, R.W., "Glass in High Speed Transport," *Glass Technology*, Vol 28 No 2, April 1987, pp. 73-81.

5) Hornsey, W.W., Rothe, W.F., "New Aircraft Windshield Applications Using Ion Exchange Glass," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

6) MIL-G-25871B, "Military Specification; Glass, Laminated, Aircraft Glazing."

7) Campbell, L.G., and Marshall, J.W., "Windshield Flight Environment Simulator," *Aircraft Engineering*, March 1976, pp. 4-9.

8) Lawrence, J.H., "Windshield Weight Reduction Through Use of High-Strength Glass and Polyurethane Interlayers," Conference on Aerospace Materials and Enclosures, Scottsdale AZ, July 11-14, 1983.

9) U.S. Federal Aviation Regulations, Paragraph 25.775, "Part 25 - Airworthiness Standards: Transport Category Airplanes."

10) U.S. Federal Aviation Regulations, Paragraph 91.117, "Part 91 - General Operating and Flight Rules."

11) McLellan G.W. and Shand, E.B., *Glass Engineering Handbook*, McGraw-Hill, New York, 1984, pp. 6-4.

12) Phillips, C.J., *Glass, Its Industrial Applications*, Reinhold Publishing Corporation, New York, 1960, pp. 82-85.

13) Greene, C.H., *Modern Glass Practice*, Cahners Books, Boston, 1975, pp.358-359.

14) Weidehorn, S.M., and Bolz, L.H., "Stress Corrosion and Static Fatigue of Glass," *Journal of the American Ceramic Society*, Vol 53, 1970, pp. 543-548.

15) Freiman, S.W., "Effects of Chemical Environment on Slow Crack Growth in Glasses and Ceramics," *Journal of Geophysical Research*, Vol 89, 1984, pp.4072-4076.

16) Stanworth, J.E., *Physical Properties of Glass*, Oxford Press, London, 1950, pp. 100-101.

17) McLellan G.W. and Shand, E.B., *Glass Engineering Handbook*, McGraw-Hill, New York, 1984, pp. 6-4 to 6-6.

Table 2.1 C/KC-135 W/WS Part Numbers

Type of Windshield	NSN	Part Number
#1 Pilot	1560-01-048-1885 FL	5-89354-501
#1 Copilot	1560-01-048-1786 FL	5-89354-502
#2 Pilot	1560-01-009-3320 FL	5-89355-501
#2 Copilot	1560-01-008-7396 FL	5-89355-502
#3 Pilot	1560-00-575-6302 FL	5-89356-501
#3 Copilot	1560-00-575-6297 FL	5-89356-502
#4 Pilot	1560-00-575-6299 FL	5-71764-501
#4 Copilot	1560-00-575-6298 FL	5-71764-502
#5 Pilot	1560-00-575-6300 FL	5-89358-501
#5 Copilot	1560-00-575-6301 FL	5-89358-502

Table 2.2 C/KC-135 Program W/WS

Type of Windshield (1-5)	S/N	Condition
1	82-H-9-6-537	repairable
1	84-H-3-19-220	repairable
1	1-H-10-5-480	repairable
1	83-H-9-19-294	**not repairable**
1	83-H-9-19-282	repairable
1	83-H-8-15-756	repairable
1	82-H-10-18-107	repairable
1	83-H-11-7-432	repairable
1	82-H-9-6-235	repairable
1	83-H-11-21-325	repairable
1	86-H-12-01-146	repairable
1	88-H-02-08-436	repairable
1	6-H-8-4-26	repairable
1	89-286-HO-697	repairable
1	82-H-10-105	repairable
1	83-H-9-19-459	repairable
1	82-H-12-6-431	repairable

Table 2.2 C/KC-135 Program W/WS continued

Type of Windshield (1-5)	S/N	Condition
2	4-H-9-27-168	repairable
2	6-H-1-15-28	repairable
2	85-H-06-03-722	repairable
2	6-H-2-27-57	**not repairable**
2	6-H-2-20-23	**not repairable**
3	5-H-3-2-730	**not repairable**
3	6-H-3-18-28	**not repairable**
3	6-H-4-6-25	**not repairable**
3	6-H-12-10-30	**not repairable**
3	B73-2815	**not repairable**
3	B73-3439	**not repairable**
3	B73-3565	**not repairable**
3	B73-2462	**not repairable**
3	85-H-01-07-725	**not repairable**
3	0-H-9-1-1140	**not repairable**
3	B73-2509	**not repairable**
3	5-H-2-16-042	**not repairable**
3	B73-3955	**not repairable**
3	4-H-10-4-02	**not repairable**
3	4-H-9-18-15	**not repairable**
3	7-H-12-13-67	**not repairable**

Table 2.2 C/KC-135 Program W/WS continued

Type of Windshield (1-5)	S/N	Condition
4	4-H-10-15-108	not repairable
4	4-H-10-9-75	not repairable
4	4-H-9-28-87	repairable
4	5-H-12-16-47	repairable
4	6-H-4-29-50	not repairable
4	8-H-2-06-585	repairable
4	87-H-04-20-130	repairable
4	7-H-1-25-01	not repairable
4	3-H-4-26-45	repairable
4	82-H-12-6-392	not repairable
4	B75-1149	repairable
4	6-H-12-02-36	not repairable
4	85-H-07-01-276	repairable
4	7-H-2-4-35	not repairable
4	90-173-HO-721	repairable
4	4-H-10-9-69	not repairable
4	4-C-02-12-10	not repairable
4	84-H-10-15-1225	repairable
4	85-H-07-01-366	repairable
4	85-H-09-02-795	not repairable
4	5-H-5-23-84	not repairable

Table 2.2 C/KC-135 Program W/WS continued

Type of Windshield (1-5)	**S/N**	**Condition**
5	4-C-5-16-11	**not repairable**
5	4-C-5-28-16	**not repairable**
5	4-H-8-30-95	repairable
5	5-H-2-5-75	**not repairable**
5	2-H-12-15-58	**not repairable**
5	H-30-67	**not repairable**
5	7-H-10-14-56	repairable
5	2-H-6-20-70	**not repairable**
5	2-H-4-24-49	**not repairable**
5	4-C-7-12-22	repairable
5	4-H-8-33-64	**not repairable**
5	5-H-12-5-05	repairable
5	4-C-6-12-13	**not repairable**
5	2-H-6-29-06	**not repairable**
5	3-H-5-23-79	repairable

Table 2.3 C/KC-135 #1 and #4 W/WS Dimensions

	#1 W/S	**#4 W/S**
Length (approx), inches	35	13
Height (approx), inches	18	10
Thickness (approx), inches	1	1
Weight (approx), pounds	46	8

Table 3.1 C/KC-135 Repaired and Not Repaired #1 W/WS in the Test Program

S/N	Repair Vendor	Vendor Damage Comments	Vendor Repair Comments
83-H-11-7-432	Perkins	delaminated	
82-H-10-18-105	Perkins	delaminated, scratched	
88-H-02-08-436	NORDAM	scratches	polish, replace bumper and pressure seal
82-H-12-6-431	NORDAM	scratches and chips	polish, replace bumper and pressure seal
1-H-10-5-480	Perkins	delaminated, scratched	
83-H-9-19-294	Perkins	delaminated	**not repairable**
82-H-9-6-537	NORDAM	scratches	polish, replace bumper and pressure seal
83-H-9-19-459	NORDAM	scratches and chips	polish, replace bumper and pressure seal
83-H-9-19-282	Perkins	delaminated	
83-H-8-15-756	Perkins	delaminated	
84-H-3-19-220	Perkins	delaminated, scratched	
86-H-12-01-146	NORDAM	scratches and chips	polish, replace bumper and pressure seal
82-H-10-18-107	Perkins	delaminated	
82-H-9-6-235	NORDAM	scratches	polish, replace bumper and pressure seal
83-H-11-21-325	NORDAM	scratches and chips	polish, replace bumper and pressure seal
89-286-HO-697	NORDAM	scratches	polish, replace bumper and pressure seal

Table 3.2 C/KC-135 Repaired and Not Repaired #4 W/WS in the Test Program

S/N	Repair Vendor	Vendor Damage Comments	Repair Comments
B75-1149	NORDAM	scratches	polish, replace bumper and pressure seals
85-H-07-01-276	NORDAM	scratches	polish, replace bumper and pressure seals
90-173-HO-721	Perkins	bad terminal block	
5-H-5-23-84	NORDAM	delamination, scratches, bad resistance	**not repairable**
7-H-2-4-35	NORDAM	scratches, bad resistance	**not repairable**
4-H-10-9-69	Perkins	contaminated	**not repairable**
82-H-12-6-392	Perkins	contaminated	**not repairable**
6-H-12-02-36	Perkins	bad resistance	**not repairable**
87-H-04-20-130	NORDAM	scratches	polish, replace bumper and pressure seals
8-H-2-06-585	Perkins	delamination, scratches	
85-H-07-01-366	NORDAM	scratches	polish, replace bumper and pressure seals
5-H-12-16-47	NORDAM	delamination, scratches	polish, autoclave, replace bumper and pressure seals
84-H-10-15-1225	NORDAM	delamination, scratches	polish, autoclave, replace bumper and pressure seals
4-H-9-28-87	NORDAM	scratches	polish, replace bumper and pressure seals
3-H-4-26-45	NORDAM	delamination, scratches, and chips	polish, autoclave, replace bumper and pressure seals
4-H-10-15-108	NORDAM	delamination, scratches, bad resistance	**not repairable**

Table 4.1 C/KC-135 #1 W/WS General Examination and Dimensional Measurements Test Results (acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
86-H-10-06-062	new	acc	acc	acc	acc	
86-H-10-06-092	new	acc	acc	acc	acc	
86-H-10-06-013	new	acc	acc	acc	acc	
86-H-10-06-048	new	acc	acc	acc	acc	
83-H-11-7-432	repaired	**REJ**	**REJ**	acc	acc	1,a
82-H-10-18-105	repaired	**REJ**	**REJ**	acc	acc	1,2,b
88-H-02-08-436	repaired	**REJ**	**REJ**	acc	acc	1,b
82-H-12-6-431	repaired	**REJ**	acc	acc	acc	1
1-H-10-5-480	repaired	**REJ**	**REJ**	acc	acc	1,c
83-H-9-19-294	not repaired	**REJ**	**REJ**	**REJ**	acc	1,2,d
82-H-9-6-537	repaired	**REJ**	**REJ**	acc	acc	1,c
83-H-9-19-459	repaired	**REJ**	**REJ**	acc	acc	1,2,b

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.1 C/KC-135 #1 W/WS General Examination and Dimensional Measurements Test Results continued (acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
86-H-10-06-007	new	acc	acc	acc	acc	
86-H-10-06-030	new	acc	acc	acc	acc	
86-H-10-06-022	new	acc	acc	acc	acc	
86-H-10-06-096	new	acc	acc	acc	acc	
83-H-9-19-282	repaired	**REJ**	**REJ**	acc	acc	3,c
83-H-8-15-756	repaired	acc	**REJ**	acc	acc	c
84-H-3-19-220	repaired	**REJ**	**REJ**	acc	acc	4,b
86-H-12-01-146	repaired	acc	**REJ**	acc	acc	c
82-H-10-18-107	repaired	**REJ**	**REJ**	acc	acc	5,b
82-H-9-6-235	repaired	**REJ**	**REJ**	acc	acc	1,2,6,b
83-H-11-21-325	repaired	**REJ**	**REJ**	acc	acc	1,b
89-286-HO-697	repaired	**REJ**	**REJ**	acc	acc	2,b

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.2 C/KC-135 #4 W/WS General Examination and Dimensional Measurements Test Results (acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
B75-1149	repaired	**REJ**	**REJ**	acc	acc	3,c
92-064-HO-471	new	acc	acc	acc	acc	
92-064-HO-473	new	acc	acc	acc	acc	
92-059-HO-350	new	acc	acc	acc	acc	
92-025-HO-006	new	acc	acc	acc	acc	
92-119-HO-186	new	acc	acc	acc	acc	
85-H-07-01-276	repaired	**REJ**	**REJ**	acc	no data	1,c
90-173-HO-721	repaired	acc	**REJ**	acc	acc	c
5-H-5-23-84	not repaired	**REJ**	**REJ**	**REJ**	acc	1,2,e,f
7-H-2-4-35	not repaired	**REJ**	**REJ**	no data	acc	1,2,f
4-H-10-9-69	not repaired	**REJ**	**REJ**	**REJ**	acc	1,g,h
82-H-12-6-392	not repaired	**REJ**	**REJ**	**REJ**	acc	1,g,h
6-H-12-02-36	not repaired	**REJ**	**REJ**	acc	acc	1,h

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.2 C/KC-135 #4 W/WS General Examination and Dimensional Measurements Test Results continued (acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Dimensional Check	Comments
87-H-04-20-130	repaired	**REJ**	**REJ**	acc	acc	6,c
8-H-2-06-585	repaired	**REJ**	**REJ**	acc	no data	1,c,i
85-H-07-01-366	repaired	**REJ**	**REJ**	acc	acc	1,c,f
92-064-HO-470	new	acc	acc	acc	acc	
92-098-HO-591	new	acc	acc	acc	acc	
92-093-HO-392	new	acc	acc	acc	acc	
92-093-HO-388	new	acc	acc	acc	acc	
5-H-12-16-47	repaired	**REJ**	**REJ**	acc	acc	1,c
84-H-10-15-1225	repaired	**REJ**	**REJ**	**REJ**	acc	1,2,c
4-H-9-28-87	repaired	**REJ**	acc	acc	acc	1
3-H-4-26-45	repaired	**REJ**	**REJ**	**REJ**	acc	1,2,f,g
4-H-10-15-108	not repaired	**REJ**	**REJ**	**REJ**	acc	1,2,

Key to Comments

1 - air and delamination at edges
2 - surface scratch(es)
3 - delamination at edges
4 - air and delamination throughout
5 - delamination in corners
6 - surface chip

a - air and water breach seal
b - seal needs to be trimmed
c - wrong seal on outboard side
d - seal falling apart
e - bad seal
f - bad bumper
g - no outboard seal
h - no outboard bumper
i - inboard bumper bad

Table 4.3 C/KC-135 #1 W/WS Basic Electrical Measurements Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Bus Resistance	Sensor Resistance	Insulation Integrity		
				bus-to-sensor	sensor-to-frame	sensor-to-sensor
86-H-10-06-062	new	acc	acc	acc	acc	acc
86-H-10-06-092	new	acc	acc	acc	acc	acc
86-H-10-06-013	new	acc	acc	acc	acc	acc
86-H-10-06-048	new	acc	acc	acc	acc	acc
83-H-11-7-432	repaired	acc	acc	acc	acc	acc
82-H-10-18-105	repaired	acc	acc	acc	acc	**REJ**
88-H-02-08-436	repaired	acc	acc	acc	acc	**REJ**
82-H-12-6-431	repaired	acc	acc	acc	acc	acc
1-H-10-5-480	repaired	acc	acc	acc	acc	acc
83-H-9-19-294	not repaired	acc	acc	acc	acc	**REJ**
82-H-9-6-537	repaired	acc	acc	acc	acc	**REJ**
83-H-9-19-459	repaired	acc	acc	acc	acc	**REJ**
86-H-10-06-007	new	acc	acc	acc	acc	acc
86-H-10-06-030	new	acc	acc	acc	acc	acc
86-H-10-06-022	new	acc	acc	acc	acc	acc
86-H-10-06-096	new	acc	acc	acc	acc	acc
83-H-9-19-282	repaired	acc	acc	acc	acc	acc
83-H-8-15-756	repaired	acc	acc	acc	acc	acc
84-H-3-19-220	repaired	acc	acc	acc	acc	**REJ**
86-H-12-01-146	repaired	acc	acc	acc	acc	acc
82-H-10-18-107	repaired	acc	acc	acc	acc	**REJ**
82-H-9-6-235	repaired	acc	acc	acc	acc	**REJ**
83-H-11-21-325	repaired	acc	acc	acc	acc	**REJ**
89-286-HO-697	repaired	acc	acc	acc	acc	**REJ**

Table 4.4 C/KC-135 #4 W/WS Basic Electrical Measurements Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Bus Resistance	Insulation Integrity bus-to-frame
B75-1149	repaired	acc	acc
92-064-HO-471	new	acc	acc
92-064-HO-473	new	acc	acc
92-059-HO-350	new	acc	acc
92-025-HO-006	new	acc	acc
92-119-HO-186	new	acc	acc
85-H-07-01-276	repaired	**REJ**	no data
90-173-HO-721	repaired	**REJ**	acc
5-H-5-23-84	not repaired	**REJ**	acc
7-H-2-4-35	not repaired	**REJ**	acc
4-H-10-9-69	not repaired	acc	acc
82-H-12-6-392	not repaired	acc	acc
6-H-12-02-36	not repaired	acc	acc
87-H-04-20-130	repaired	acc	acc
8-H-2-06-585	repaired	acc	acc
85-H-07-01-366	repaired	acc	acc
92-064-HO-470	new	acc	acc
92-098-HO-591	new	acc	acc
92-093-HO-392	new	acc	acc
92-093-HO-388	new	acc	acc
5-H-12-16-47	repaired	**REJ**	acc
84-H-10-15-1225	repaired	acc	acc
4-H-9-28-87	repaired	acc	acc
3-H-4-26-45	repaired	acc	acc
4-H-10-15-108	not repaired	**REJ**	acc

Table 4.5 C/KC-135 #1 W/WS Heater Operation Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Heater Operation	Hot/Cold Spots	Heater Film Scratch Test
86-H-10-06-062	new	90-110° F	no	acc
86-H-10-06-092	new	90-115° F	no	acc
86-H-10-06-013	new	90-110° F	no	acc
86-H-10-06-048	new	90-110° F	no	acc
83-H-11-7-432	repaired	85-115° F	no	acc
82-H-10-18-105	repaired	85-110° F	no	acc
88-H-02-08-436	repaired	90-110° F	no	acc
82-H-12-6-431	repaired	95-120° F	no	acc
1-H-10-5-480	repaired	90-115° F	no	acc
83-H-9-19-294	not repaired	no test	-	acc
82-H-9-6-537	repaired	80-140° F	no	acc
83-H-9-19-459	repaired	90-110° F	no	acc
86-H-10-06-007	new	90-115° F	no	acc
86-H-10-06-030	new	90-115° F	no	acc
86-H-10-06-022	new	missing photo	-	acc
86-H-10-06-096	new	90-110° F	no	acc
83-H-9-19-282	repaired	90-115° F	no	acc
83-H-8-15-756	repaired	90-115° F	no	acc
84-H-3-19-220	repaired	90-110° F	no	acc
86-H-12-01-146	repaired	95-120° F	no	acc
82-H-10-18-107	repaired	90-115° F	no	acc
82-H-9-6-235	repaired	90-115° F	no	acc
83-H-11-21-325	repaired	90-115° F	no	acc
89-286-HO-697	repaired	90-115° F	no	acc

Table 4.6 C/KC-135 #4 W/WS Heater Operation Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Heater Operation	Hot/Cold Spots	Heater Film Scratch Test
B75-1149	repaired	95-115° F	no	acc
92-064-HO-471	new	95-110° F	no	acc
92-064-HO-473	new	95-120° F	no	acc
92-059-HO-350	new	95-110° F	no	acc
92-025-HO-006	new	95-110° F	no	acc
92-119-HO-186	new	missing photo	-	acc
85-H-07-01-276	repaired	no test	-	**REJ**
90-173-HO-721	repaired	no test	-	acc
5-H-5-23-84	not repaired	95-115° F	no	acc
7-H-2-4-35	not repaired	95-115° F	no	acc
4-H-10-9-69	not repaired	95-110° F	no	acc
82-H-12-6-392	not repaired	95-115° F	no	acc
6-H-12-02-36	not repaired	95-110° F	no	acc
87-H-04-20-130	repaired	95-110° F	no	acc
8-H-2-06-585	repaired	95-110° F	no	acc
85-H-07-01-366	repaired	missing photo	-	acc
92-064-HO-470	new	95-110° F	no	acc
92-098-HO-591	new	95-115° F	no	acc
92-093-HO-392	new	95-135° F	no	acc
92-093-HO-388	new	95-110° F	no	acc
5-H-12-16-47	repaired	95-110° F	no	acc
84-H-10-15-1225	repaired	95-110° F	no	acc
4-H-9-28-87	repaired	95-110° F	no	acc
3-H-4-26-45	repaired	95-110° F	no	acc
4-H-10-15-108	not repaired	95-115° F	no	acc

Table 4.7 C/KC-135 #1 W/WS Optical Performance Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Luminous Transmittance	Haze	Deviation	Distortion, center/edge
86-H-10-06-062	new	acc	acc	acc	none/1:30
86-H-10-06-092	new	acc	acc	acc	none/none
86-H-10-06-013	new	acc	acc	acc	none/none
86-H-10-06-048	new	acc	acc	acc	none/none
83-H-11-7-432	repaired	acc	acc	acc	none/1:20
82-H-10-18-105	repaired	acc	acc	acc	none/none
88-H-02-08-436	repaired	acc	acc	acc	none/none
82-H-12-6-431	repaired	acc	acc	acc	none/none
1-H-10-5-480	repaired	acc	acc	acc	none/none
83-H-9-19-294	not repaired	acc	acc	acc	none/none
82-H-9-6-537	repaired	acc	acc	acc	none/none
83-H-9-19-459	repaired	acc	acc	acc	none/none
86-H-10-06-007	new	acc	acc	acc	none/none
86-H-10-06-030	new	acc	acc	acc	none/none
86-H-10-06-022	new	acc	acc	acc	none/none
86-H-10-06-096	new	acc	acc	acc	none/none
83-H-9-19-282	repaired	acc	acc	acc	none/none
83-H-8-15-756	repaired	acc	acc	acc	none/none
84-H-3-19-220	repaired	acc	acc	acc	none/none
86-H-12-01-146	repaired	acc	acc	acc	none/1:30
82-H-10-18-107	repaired	acc	acc	acc	none/1:40
82-H-9-6-235	repaired	acc	acc	acc	none/none
83-H-11-21-325	repaired	acc	acc	acc	none/none
89-286-HO-697	repaired	acc	acc	acc	none/none

Table 4.8 C/KC-135 #4 W/WS Optical Performance Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Luminous Transmittance	Haze	Deviation	Distortion, center/edge
B75-1149	repaired	acc	acc	acc	none/1:18
92-064-HO-471	new	acc	acc	acc	none/1:11
92-064-HO-473	new	acc	acc	acc	none/1:14
92-059-HO-350	new	acc	acc	acc	none/1:7
92-025-HO-006	new	acc	acc	acc	none/1:8
92-119-HO-186	new	acc	acc	acc	missing photo
85-H-07-01-276	repaired	acc	acc	acc	none/1:12
90-173-HO-721	repaired	acc	acc	acc	none/1:10
5-H-5-23-84	not repaired	acc	acc	acc	none/none
7-H-2-4-35	not repaired	acc	acc	acc	none/1:25
4-H-10-9-69	not repaired	acc	acc	acc	none/1:21
82-H-12-6-392	not repaired	acc	acc	acc	none/1:7
6-H-12-02-36	not repaired	acc	acc	acc	none/none
87-H-04-20-130	repaired	acc	acc	acc	1:16/1:5
8-H-2-06-585	repaired	acc	acc	acc	none/1:22
85-H-07-01-366	repaired	acc	acc	acc	none/1:8
92-064-HO-470	new	acc	acc	acc	none/1:12
92-098-HO-591	new	acc	acc	acc	none/1:9
92-093-HO-392	new	acc	acc	acc	none/1:10
92-093-HO-388	new	acc	acc	acc	none/1:9
5-H-12-16-47	repaired	acc	acc	acc	none/none
84-H-10-15-1225	repaired	acc	acc	acc	none/1:6
4-H-9-28-87	repaired	acc	acc	acc	none/1:16
3-H-4-26-45	repaired	acc	acc	acc	none/none
4-H-10-15-108	not repaired	acc	acc	acc	1:16/1:22

Table 4.9 C/KC-135 #1 W/WS Pressure Integrity Test Results

S/N	Type	Initial Proof Pressure Test	Damage from Pressure Cycling	Final Proof Pressure Test
86-H-10-06-062	new	passed	no apparent damage	passed
86-H-10-06-092	new	passed	no apparent damage	passed
86-H-10-06-013	new	passed	no apparent damage	passed
86-H-10-06-048	new	passed	no apparent damage	passed
83-H-11-7-432	repaired	passed	no apparent damage	passed
81-H-10-18-105	repaired	passed	no apparent damage	passed
88-H-02-08-436	repaired	passed	no apparent damage	passed
82-H-12-6-431	repaired	passed	no apparent damage	passed
1-H-10-5-480	repaired	passed	no apparent damage	passed
83-H-9-19-294	not repaired	passed	no apparent damage	passed
82-H-9-6-537	repaired	passed	delamination near slip plane areas	passed
83-H-9-19-459	repaired	passed	delamination near slip plane areas	passed

Table 4.10 C/KC-135 #4 W/WS Pressure Integrity Test Results

S/N	Type	Initial Proof Pressure Test	Damage from Pressure Cycling	Final Proof Pressure Test
87-H-04-20-130	repaired	passed	no apparent damage	passed
8-H-2-06-585	repaired	passed	no apparent damage	passed
85-H-07-01-366	repaired	passed	no apparent damage	passed
92-064-HO-470	new	passed	no apparent damage	passed
92-098-HO-591	new	passed	no apparent damage	passed
92-093-HO-392	new	passed	no apparent damage	passed
92-093-HO-388	new	passed	no apparent damage	passed
5-H-12-16-47	repaired	passed	large amount of delamination along forward edge and lower forward corner	passed
84-H-10-15-1225	repaired	passed	no apparent damage	passed
4-H-9-28-87	repaired	passed	no apparent damage	passed
3-H-4-26-45	repaired	passed	delamination in lower forward corner of less than 1 square inch	passed
4-H-10-15-108	not repaired	passed	no apparent damage	passed

Table 4.11 C/KC-135 #1 W/WS Residual Strength Ball Drop Test Results

W/WS S/N	Type	Damage from Pressure Cycling	Comments
86-H-10-06-062	new	no apparent damage	Two ball drops. Outboard glass ply broken. Crushing in impact area. No delamination created by cracking of the outer ply.
83-H-9-19-459	repaired	delamination near slip plane areas	Two ball drops. Outboard glass ply broken. Core ply intact. No delamination from glass breakage.
1-H-10-5-480	repaired	no apparent damage	Two ball drops. Outboard glass ply broken. No delamination from outer ply cracking.
81-H-10-18-105	repaired	no apparent damage	One ball drop only. Both glass plies failed. Large amount of spall driven from core ply inboard surface.
82-H-9-6-537	repaired	delamination near slip plane areas	One ball drop only. Both glass plies failed. Large amount of spall removed from core ply surface.

Table 4.12 C/KC-135 #4 W/WS Residual Strength Ball Drop Test Results

W/WS S/N	Type	Damage from Pressure Cycling	Comments
92-093-HO-388	new	no apparent damage	Outboard glass ply broken. Core ply intact. No delamination associated with glass breaking.
87-H-04-20-130	repaired	no apparent damage	Outboard glass ply broken. Core ply intact. No delamination associated with glass breaking.
8-H-2-06-585	repaired	no apparent damage	Outboard glass ply broken. Core ply intact. No delamination associated with glass breaking.
3-H-4-26-45	repaired	delamination in lower forward corner of less than 1 square inch	Both glass plies failed. Large area of core ply inboard surface spalled in impact area.
5-H-12-16-47	repaired	large amount of delamination along forward edge and lower forward corner	Both glass plies failed. Large area of core ply inboard surface spalled in impact area.

Table 4.13 C/KC-135 #1 W/WS Bird Impact Test Results

Date	Shot Number	S/N	Type	Impact Velocity (knots)	Comments
6/22/93	783	86-H-10-06-007	new	251.7	Outboard glass ply broken. Core ply intact. Small amount of bird residue impacted spall sheet - entry between outboard glass ply and W/WS frame when mounting O-rings compressed.
6/22/93	784	86-H-10-06-030	new	251.1	No damage. Small amount of bird residue on spall sheet, same as Shot 783.
6/23/93	785	86-H-10-06-22	new	252.8	No damage. No bird residue on spall sheet.
6/23/93	786	86-H-10-06-96	new	252.6	No damage. No bird residue on spall sheet.
6/24/93	792	83-H-9-19-2-282	repaired	249.6	Outboard ply intact. Core ply failed. No glass spall on spall sheet.
7/19/93	793	83-H-8-15-756	repaired	249.4	All glass plies failed. Minor glass spall on spall sheet.
7/19/93	794	84-H-3-19-220	repaired	250.1	Outboard glass ply failed. Core ply intact.
7/20/93	795	86-H-12-01-146	repaired	252.4	No glass breakage. Z-bar retainer bent badly.
7/20/93	796	82-H-10-18-107	repaired	249.4	All glass plies failed. Minor amount of glass spall from inboard ply on spall sheet.
7/20/93	797	82-H-9-6-235	repaired	251.0	Outboard glass ply failed. Core ply intact.
7/21/93	798	83-H-11-21-325	repaired	247.5	All glass plies failed. No spall on spall sheet.
7/22/93	799	89-286-HO-697	repaired	250.8	No damage.

Table 4.14 C/KC-135 #4 W/WS Bird Impact Test Results

Date	Shot Number	S/N	Type	Impact Velocity (knots)	Comments
9/1/93	815	B75-1149	repaired	247.5	Outboard glass ply failed. Bird residue between outboard retainer gasket along aft edge and top right corner. Bent bolts.
9/1/93	816	92-064-HO-471	new	251.3	No damage. Small amount of bird residue between outboard retainer and W/WS. No bent bolts.
9/1/93	817	92-064-HO-473	new	248.9	No damage. Minor bird residue through aft edge.
9/1/93	818	92-059-HO-350	new	225.1	Bird cannon misfire due to camera failure. Inboard glass ply chipped.
9/29/93	835	92-025-HO-006	new	248.4	No damage.
9/29/93	836	92-119-HO-186	new	247.8	No damage.
9/29/93	837	85-H-07-01-276	repaired	248.7	No damage.
9/29/93	838	90-173-HO-721	repaired	247.1	No damage.
9/30/93	839	5-H-5-23-84	not repaired	251.2	Outboard ply broken. No bird penetration. Interlayer tear in lower forward corner.
9/30/93	840	7-H-2-4-35	not repaired	250.8	Catastrophic failure. Entire laminated panel torn out at insert.
9/30/93	841	4-H-10-9-69	not repaired	251.0	No damage.
9/30/93	842	82-H-12-6-392	not repaired	250.8	No damage.
10/1/93	843	6-H-12-02-36	not repaired	250.3	All glass plys failed. 4-inch long interlayer tear at lower forward corner. Some glass spall.

Table 4.15 C/KC-135 W/WS General Inspection Summary

	#1 W/WS			#4 W/WS		
Category	New	Repaired	Not Repaired	New	Repaired	Not Repaired
Number Tested	8	15	1	9	10	6
Number with delamination, scratches, or chips	0	13	1	0	9	6
Number with seal deficiencies	0	14	1	0	8	6
Number with vinyl cracks	0	0	1	0	2	4
Number with bad dimensional check	0	0	0	0	0	0
Number with bad bus resistance	0	0	0	0	3	3
Number with bad sensor resistance	0	0	0	–	–	–
Number with bad insulation	0	9	1	0	0	0
Number with poor heater performance	0	0	1	0	1	0
Number with bad optics	0	0	0	0	0	0

Table 4.16 C/KC-135 W/WS Pressure Integrity Test Summary

	#1 W/WS			#4 W/WS		
Category	New	Repaired	Not Repaired	New	Repaired	Not Repaired
Number Tested	4	7	1	4	7	1
Number failing initial proof pressure test	0	0	0	0	0	0
Number failing during pressure cycling	0	0	0	0	0	0
Number failing final proof pressure test	0	0	0	0	0	0
Number delaminated	0	2	0	0	2	0

Table 4.17 C/KC-135 W/WS Ball Drop Residual Strength Test Summary

	#1 W/WS		#4 W/WS	
Category	New	Repaired	New	Repaired
Number Tested	1	4	1	4
Number with initial delamination	0	2	0	2
Number with outboard ply failure only	1	2	1	2
Number with both glass plys failed	0	2	0	2

Table 4.18 C/KC-135 W/WS Bird Impact Test Summary

	#1 W/WS		#4 W/WS		
Category	New	Repaired	New	Repaired	Not Repaired
Number Tested	4	8	5	3	5
Number undamaged	3	2	4	2	2
Number with outboard ply broken only	1	2	1	1	1
Number with inboard ply broken only	0	1	0	0	0
Number with all glass plies failed	0	3	0	0	2
Number with no inner ply glass spall	4	6	5	3	3
Number with minor inner ply glass spall	0	2	0	0	1
Number with major inner ply glass spall	0	0	0	0	1
Number with no bird penetration	4	8	5	3	4
Number with minor bird penetration	0	0	0	0	0
Number with major bird penetration	0	0	0	0	1

Table 4.19 C/KC-135 #1 W/WS Mounting Edge Measurements and Bird Impact Test Results

<table>
<tr><th>S/N</th><th>Type</th><th>Edge Thickness, inches</th><th>Bird Impact Comments</th></tr>
<tr><td>86-H-10-06-007</td><td>new</td><td>0.936
0.943
0.942</td><td>Outboard glass ply broken. Core ply intact.</td></tr>
<tr><td>82-H-10-18-107</td><td>repaired</td><td>0.843
0.852
0.838</td><td>All glass plies failed. Minor amount of glass spall from inboard ply on spall sheet.</td></tr>
<tr><td>83-H-9-19-282</td><td>repaired</td><td>similar to
82-H-10-18-107</td><td>Core ply failed. No glass spall on spall sheet.</td></tr>
<tr><td>83-H-8-15-756</td><td>repaired</td><td>similar to
82-H-10-18-107</td><td>All glass plies failed. Minor glass spall on spall sheet.</td></tr>
<tr><td>83-H-11-21-325</td><td>repaired</td><td>0.927
0.936
0.939</td><td>All glass plies failed. No spall on spall sheet.</td></tr>
<tr><td>86-H-06-030
86-H-10-06-22
86-H-10-06-96</td><td>new</td><td rowspan="5">0.908 min
0.940 max</td><td>No damage.</td></tr>
<tr><td>84-H-3-19-220</td><td rowspan="4">repaired</td><td>Outboard glass ply failed.</td></tr>
<tr><td>86-H-12-01-146</td><td>No glass breakage.</td></tr>
<tr><td>82-H-9-6-235</td><td>Outboard glass ply failed.</td></tr>
<tr><td>89-286-HO-697</td><td>No damage.</td></tr>
<tr><td>91-010-HO-206</td><td rowspan="5">unrepaired</td><td>0.850 min
0.909 max</td><td rowspan="5">Not bird impact tested.</td></tr>
<tr><td>87-H-06-29-758</td><td>0.893 min
0.920 max</td></tr>
<tr><td>87-H-09-21-671</td><td>0.886 min
0.922 max</td></tr>
<tr><td>90-180-HO-139</td><td>0.839 min
0.887 max</td></tr>
<tr><td>82-H-9-20-127</td><td>0.902 min
0.918 max</td></tr>
</table>

Table 5.1 Initial C/KC-135 W/WS Repair Estimates

Type of W/WS		NORDAM[a]	Perkins[b]	The Glass Doctor[b]
1		$1,890	$2,000	$1,327[c]
2	glass only	$1,512	$1,500	$896
	frame and glass	$6,700	-	-
3		$735 Category I[d] $945 Category II $945 Category III $1,280 Category IV	$750	$516
4		$975	$875	$667
5		$750	$875	$484

Notes:

a) Estimate, actual price quote based on specific repairs required as determined by incoming inspection.
b) Fixed price.
c) Sensor repair or replacement, $437 additional.
d) NORDAM #3 W/WS Repair/Overhaul Categories:

All repair categories include complete disassembly, inspection, and reassembly with new seal and new grommets.

Category	Transparency Repair
I	Polish inner and outer panes
II	Polish outer pane, replace inner pane
III	Polish inner pane, replace outer pane
IV	Replace inner and outer panes

Table 5.2 C/KC-135 #1 W/WS Actual Repair Costs (NR=not repairable)

S/N	Repair Vendor	Vendor Damage Comments	Repair Cost
83-H-11-7-432	Perkins	delaminated	$2,000
82-H-10-18-105	Perkins	delaminated, scratched	$2,000
88-H-02-08-436	NORDAM	scratches	$1,695
82-H-12-6-431	NORDAM	scratches and chips	$2,090
1-H-10-5-480	Perkins	delaminated, scratched	$2,000
83-H-9-19-294	Perkins	delaminated	$0, **NR**
82-H-9-6-537	NORDAM	scratches	$1,893
83-H-9-19-459	NORDAM	scratches and chips	$1,893
83-H-9-19-282	Perkins	delaminated	$2,000
83-H-8-15-756	Perkins	delaminated	$2,000
84-H-3-19-220	Perkins	delaminated, scratched	$2,000
86-H-12-01-146	NORDAM	scratches and chips	$1,695
82-H-10-18-107	Perkins	delaminated	$2,000
82-H-9-6-235	NORDAM	scratches	$1,695
83-H-11-21-325	NORDAM	scratches and chips	$2,090
89-286-HO-697	NORDAM	scratches	$2,090

Table 5.3 C/KC-135 #4 W/WS Actual Repair Costs (**NR**=not repairable)

S/N	**Repair Vendor**	**Vendor Damage Comments**	**Repair Cost**
B75-1149	NORDAM	scratches	$559
85-H-07-01-276	NORDAM	scratches	$954
90-173-HO-721	Perkins	bad terminal block	$875
5-H-5-23-84	NORDAM	delamination, scratches, bad resistance	$0, **NR**
7-H-2-4-35	NORDAM	scratches, bad resistance	$0, **NR**
4-H-10-9-69	Perkins	contaminated	$0, **NR**
82-H-12-6-392	Perkins	contaminated	$0, **NR**
6-H-12-02-36	Perkins	bad resistance	$0, **NR**
87-H-04-20-130	NORDAM	scratches	$954
8-H-2-06-585	Perkins	delamination, scratches	$875
85-H-07-01-366	NORDAM	scratches	$559
5-H-12-16-47	NORDAM	delamination, scratches	$1,151
84-H-10-15-1225	NORDAM	delamination, scratches	$1,151
4-H-9-28-87	NORDAM	scratches	$559
3-H-4-26-45	NORDAM	delamination, scratches, and chips	$1,349
4-H-10-15-108	NORDAM	delamination, scratches, bad resistance	$0, **NR**

Table 5.4 Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS
(**NR**=not repairable)

Type of W/WS (1-5)	S/N	Repair Vendor	Cost of Repair
1	82-H-9-6-537	NORDAM	$1,893
1	84-H-3-19-220	Perkins	$2,000
1	1-H-10-5-480	Perkins	$2,000
1	83-H-9-19-294	Perkins	$0, **NR**
1	83-H-9-19-282	Perkins	$2,000
1	83-H-8-15-756	Perkins	$2,000
1	82-H-10-18-107	Perkins	$2,000
1	83-H-11-7-432	Perkins	$2,000
1	82-H-9-6-235	NORDAM	$1,695
1	83-H-11-21-325	NORDAM	$2,090
1	86-H-12-01-146	NORDAM	$2,090
1	88-H-02-08-436	NORDAM	$1,695
1	6-H-8-4-26	NORDAM	$2,683
1	89-286-HO-697	NORDAM	$2,090
1	82-H-10-105	Perkins	$2,000
1	83-H-9-19-459	NORDAM	$1,893
1	82-H-12-6-431	NORDAM	$2,090
2	4-H-9-27-168	NORDAM	$1,919
2	6-H-1-15-28	NORDAM	$1,524
2	85-H-06-03-722	NORDAM	$1,721
2	6-H-2-27-57	Perkins	$0, **NR**
2	6-H-2-20-23	Perkins	$0, **NR**
3	5-H-3-2-730	NORDAM	$0, **NR**
3	6-H-3-18-28	NORDAM	$0, **NR**
3	6-H-4-6-25	NORDAM	$0, **NR**
3	6-H-12-10-30	NORDAM	$0, **NR**
3	B73-2815	Perkins	$0, **NR**
3	B73-3439	Perkins	$0, **NR**

Table 5.4 **Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS** continued
(**NR**=not repairable)

Type of W/WS (1-5)	S/N	Repair Vendor	Cost of Repair
3	B73-3565	Perkins	$0, **NR**
3	B73-2462	NORDAM	$0, **NR**
3	85-H-01-07-725	Perkins	$0, **NR**
3	0-H-9-1-1140	NORDAM	$0, **NR**
3	B73-2509	Perkins	$0, **NR**
3	5-H-2-16-042	NORDAM	$0, **NR**
3	B73-3955	Perkins	$0, **NR**
3	4-H-10-4-02	Perkins	$0, **NR**
3	4-H-9-18-15	Perkins	$0, **NR**
3	7-H-12-13-67	NORDAM	$0, **NR**
4	4-H-10-15-108	NORDAM	$0, **NR**
4	4-H-10-9-75	Perkins	$0, **NR**
4	4-H-9-28-87	NORDAM	$559
4	5-H-12-16-47	NORDAM	$1,151
4	6-H-4-29-50	Perkins	$0, **NR**
4	8-H-2-06-585	Perkins	$875
4	87-H-04-20-130	NORDAM	$954
4	7-H-1-25-01	Perkins	$0, **NR**
4	3-H-4-26-45	NORDAM	$1,349
4	82-H-12-6-392	Perkins	$0, **NR**
4	B75-1149	NORDAM	$559
4	6-H-12-02-36	Perkins	$0, **NR**
4	85-H-07-01-276	NORDAM	$954
4	7-H-2-4-35	NORDAM	$0, **NR**
4	90-173-HO-721	Perkins	$875
4	4-H-10-9-69	Perkins	$0, **NR**
4	4-C-02-12-10	Perkins	$0, **NR**
4	84-H-10-15-1225	NORDAM	$1,151

Table 5.4 Cost Quotes for All Prototype Repair Candidate C/KC-135 W/WS continued
(**NR**=not repairable)

Type of W/WS (1-5)	S/N	Repair Vendor	Cost of Repair
4	85-H-07-01-366	NORDAM	$559
4	85-H-09-02-795	Perkins	$0, **NR**
4	5-H-5-23-84	NORDAM	$0, **NR**
5	4-C-5-16-11	Perkins	$0, **NR**
5	4-C-5-28-16	NORDAM	$0, **NR**
5	4-H-8-30-95	NORDAM	$486
5	5-H-2-5-75	Perkins	$0, **NR**
5	2-H-12-15-58	NORDAM	$0, **NR**
5	H-30-67	NORDAM	$0, **NR**
5	7-H-10-14-56	NORDAM	$1,079
5	2-H-6-20-70	Perkins	$0, **NR**
5	2-H-4-24-49	Perkins	$0, **NR**
5	4-C-7-12-22	NORDAM	$881
5	4-H-8-33-64	Perkins	$0, **NR**
5	5-H-12-5-05	NORDAM	$486
5	4-C-6-12-13	Perkins	$0, **NR**
5	2-H-6-29-06	Perkins	$0, **NR**
5	3-H-5-23-79	NORDAM	$881

Table 5.5 C/KC-135 New W/WS Costs

Designation	NSN	Part Number	USAF Cost
#1 Pilot	1560-01-048-1885 FL	5-89354-501	$2,582
#1 Copilot	1560-01-048-1786 FL	5-89354-502	
#2 Pilot	1560-01-009-3320 FL	5-89355-501	$1,445
#2 Copilot	1560-01-008-7396 FL	5-89355-502	
#3 Pilot	1560-00-575-6302 FL	5-89356-501	$1,479
#3 Copilot	1560-00-575-6297 FL	5-89356-502	
#4 Pilot	1560-00-575-6299 FL	5-71764-501	$1,372
#4 Copilot	1560-00-575-6298 FL	5-71764-502	
#5 Pilot	1560-00-575-6300 FL	5-89358-501	$1,078
#5 Copilot	1560-00-575-6301 FL	5-89358-502	

Table 5.6 Repair Cost Comparison Data for C/KC-135 W/WS

Type of W/WS	Cost as a Percentage of New Purchase Price		
	High*	Actual	Low*
1	81	75	61
2	132	-	83
3	87	-	41
4	71	65	41
5	100	-	45

* Based on Extremes of Estimates, Actual Costs, and Quotes from NORDAM and Perkins Aircraft Services, assuming a 20-percent volume discount from Perkins

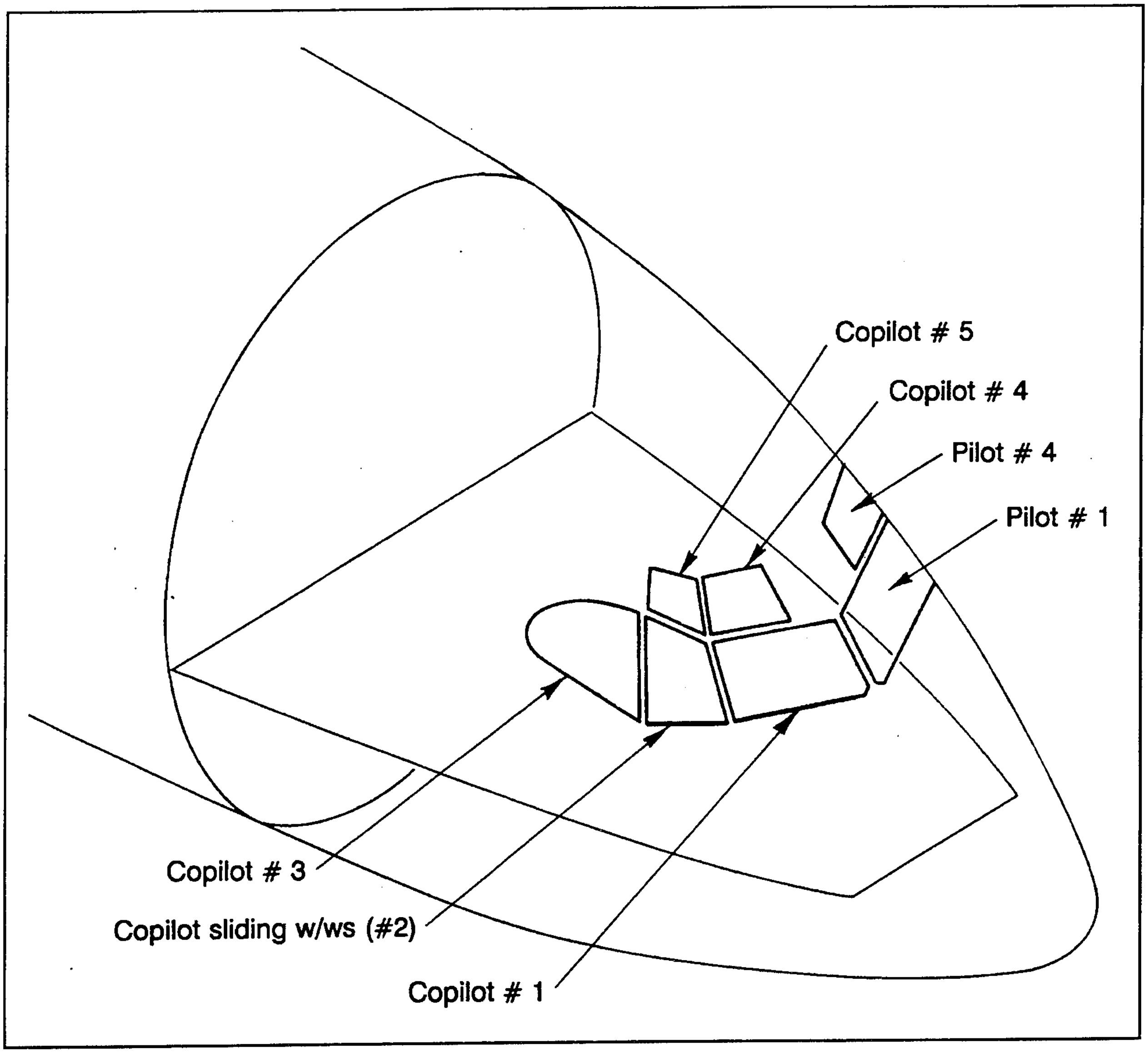


Figure 2.1 C/KC-135 W/WS Identification

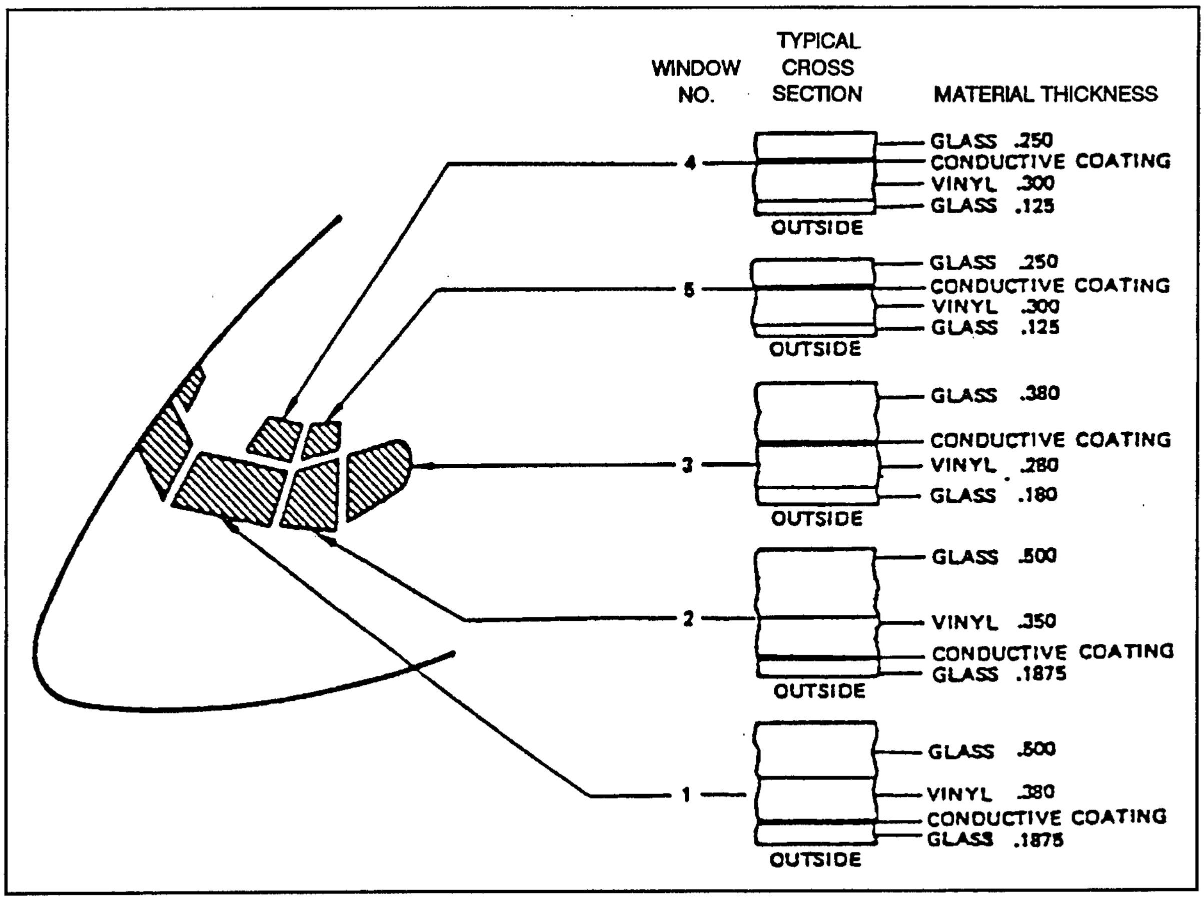


Figure 2.2 C/KC-135 W/WS Construction

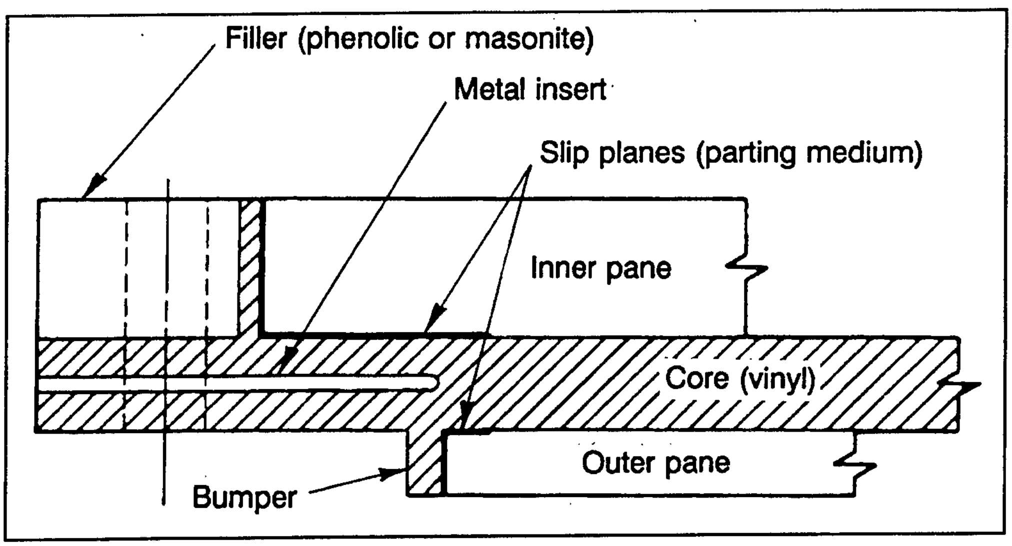


Figure 2.3 W/WS Construction Showing Location of Slip Planes

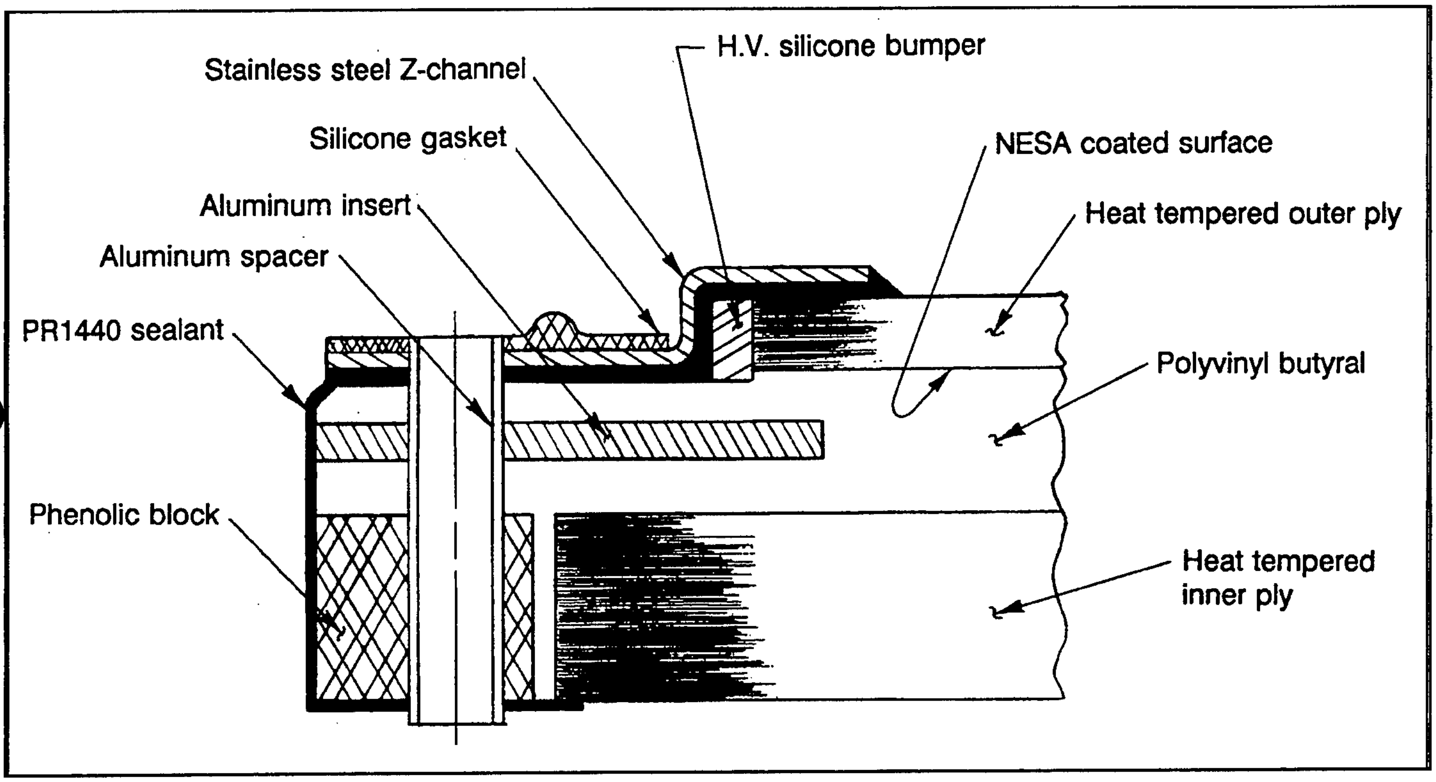


Figure 2.4 C/KC-135 #1 W/WS Cross-Section

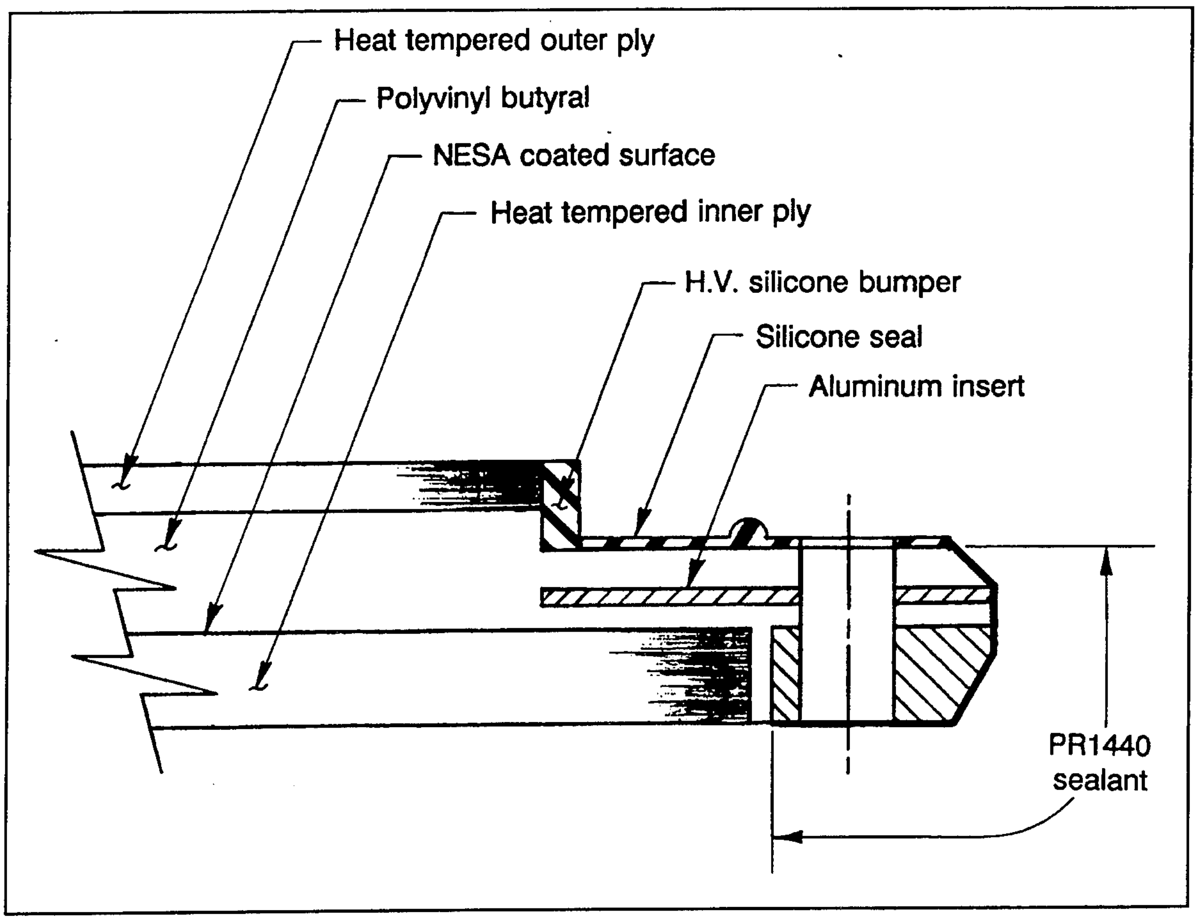


Figure 2.5 C/KC-135 #4 W/WS Cross-Section

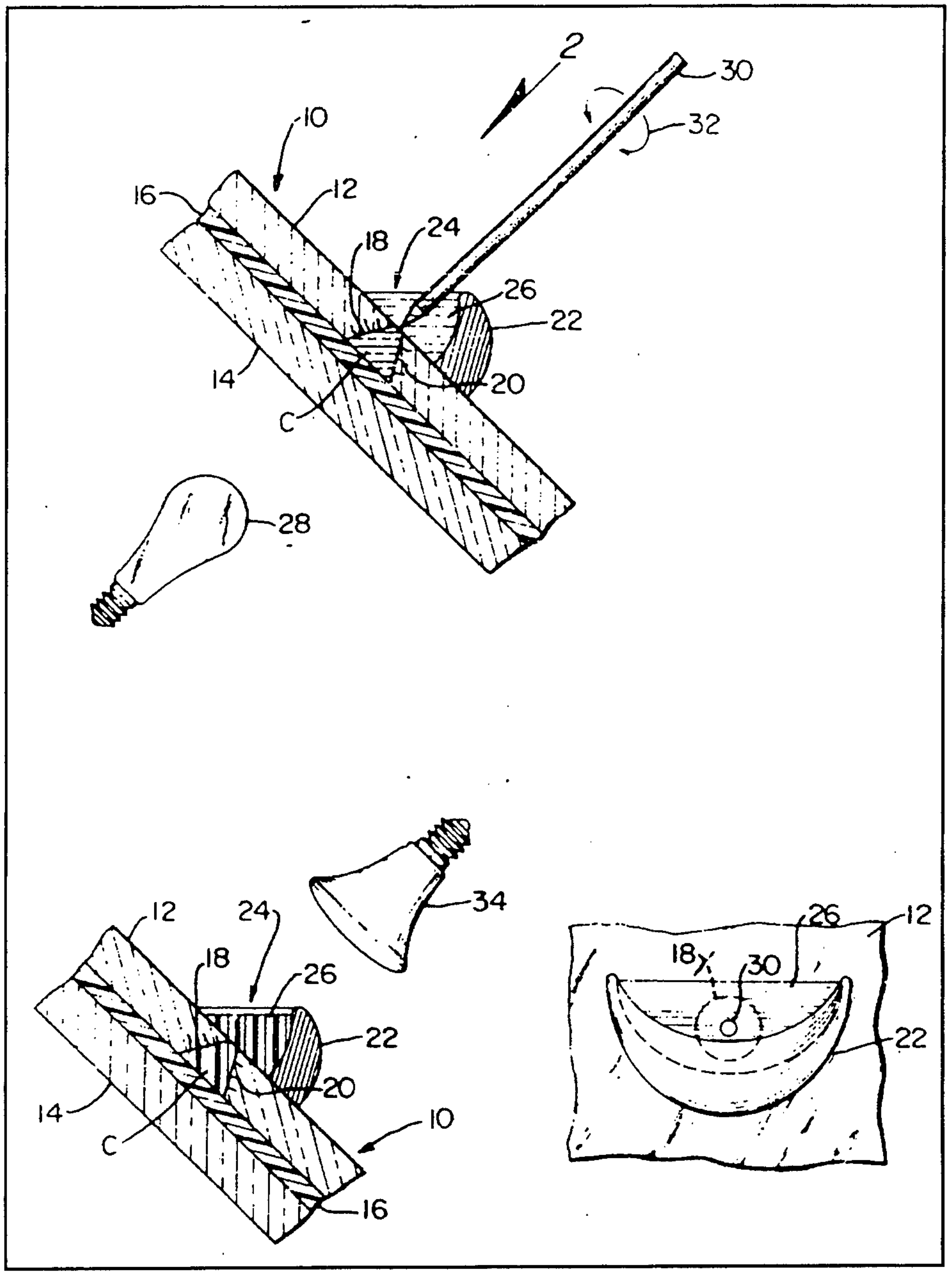


Figure 3.1 The Glass Doctor Patented Technique for Repair of Conical Cracks in Laminated Glass, U.S. Patent # 3,841,932

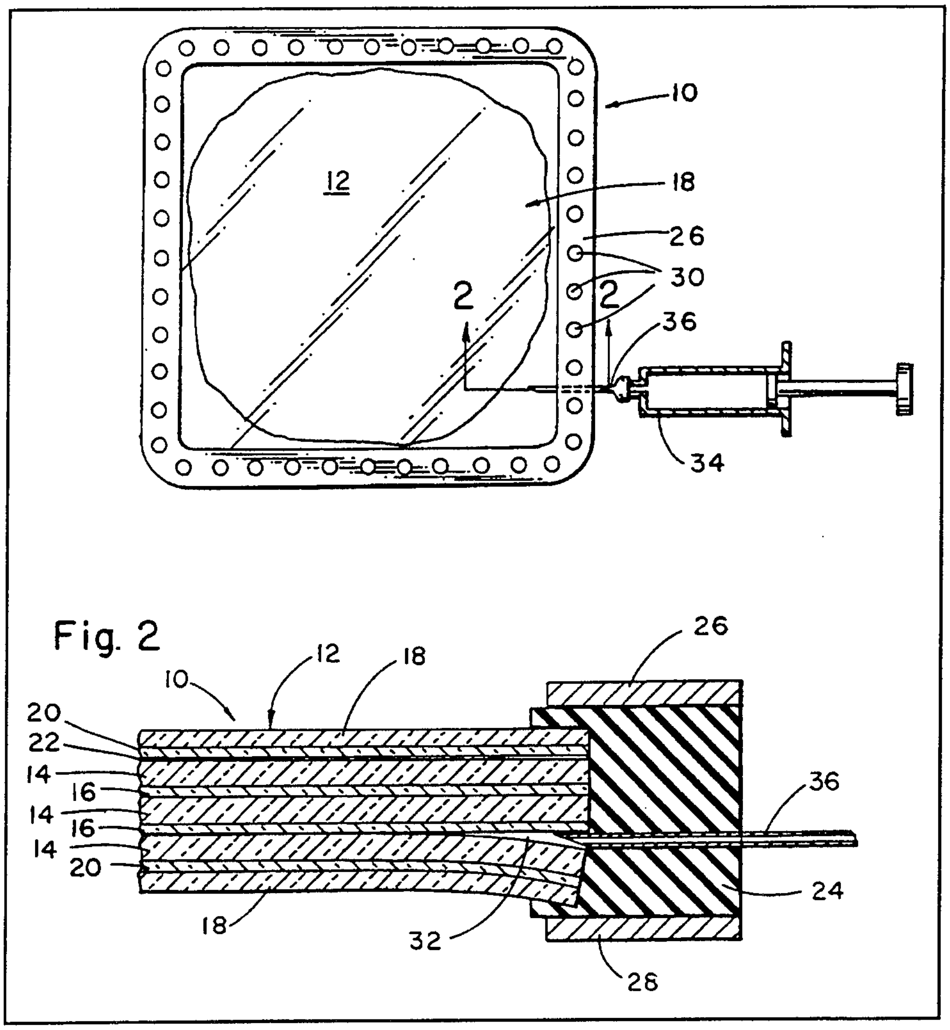
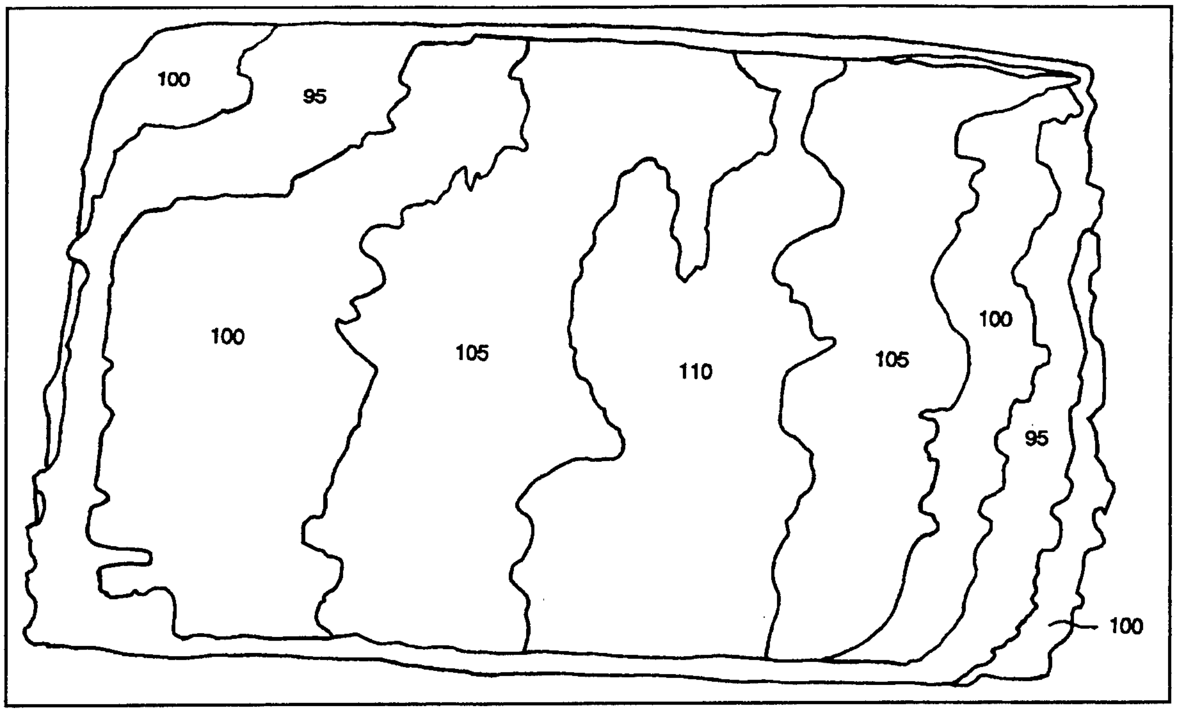
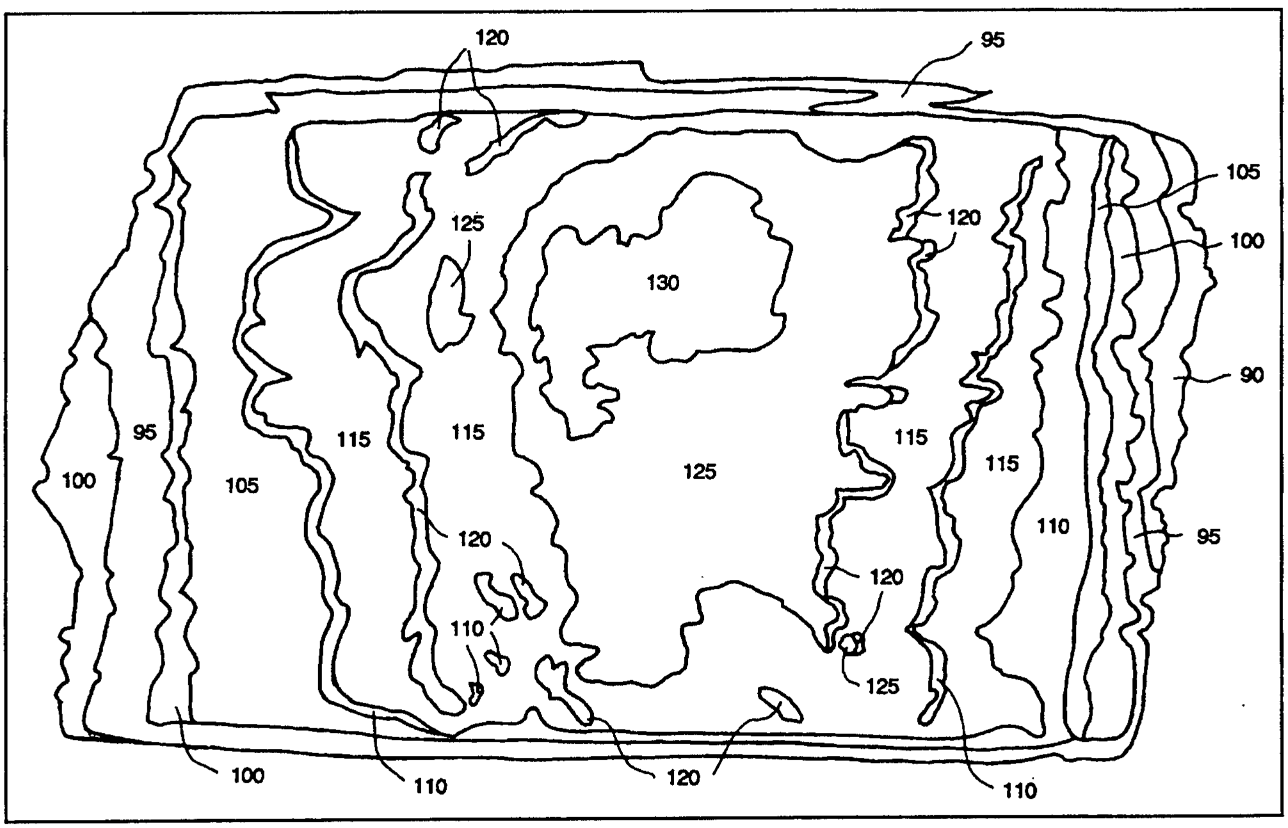


Figure 3.2 The Glass Doctor Patented Technique for Repair of Delaminations, U.S. Patent # 4,780,162

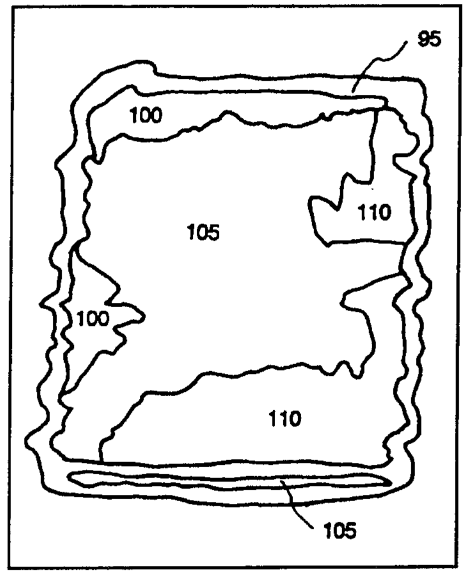


a) Typical (S/N 86-H-10-06-062)

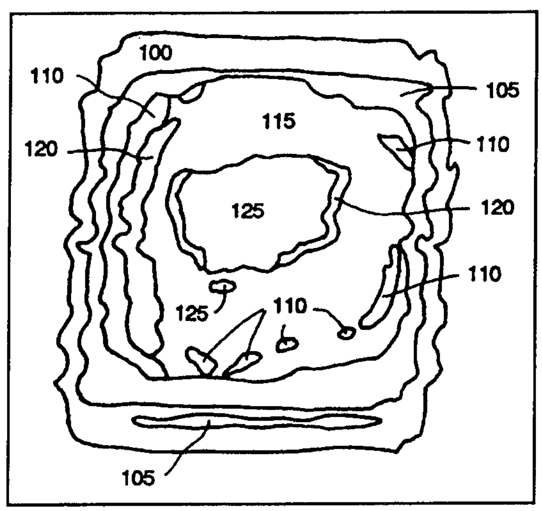


b) Most Out-of-the-Ordinary (S/N 82-H-9-6-537)

Figure 4.1 C/KC-135 #1 Thermal Images From the Heater Test



a) Typical (S/N 92-064-HO-471)



b) Most Out-of-the-Ordinary (S/N 92-093-HO-392)

Figure 4.2 C/KC-135 #4 W/WS Thermal Images From the Heater Test

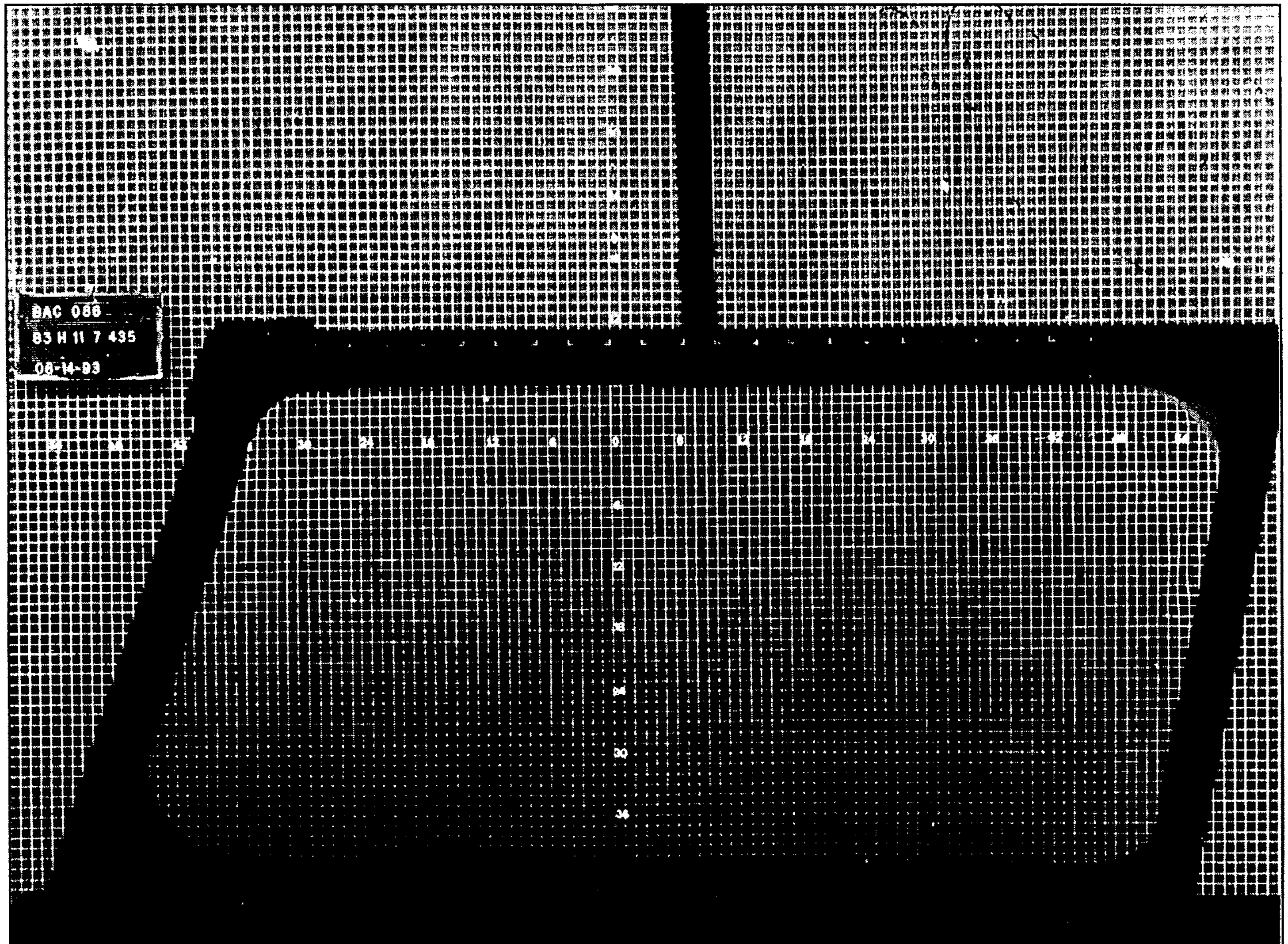


Figure 4.3 Worst Optical Distortion Found in Any C/KC-135 #1 W/WS (S/N 83-H-11-7-432)

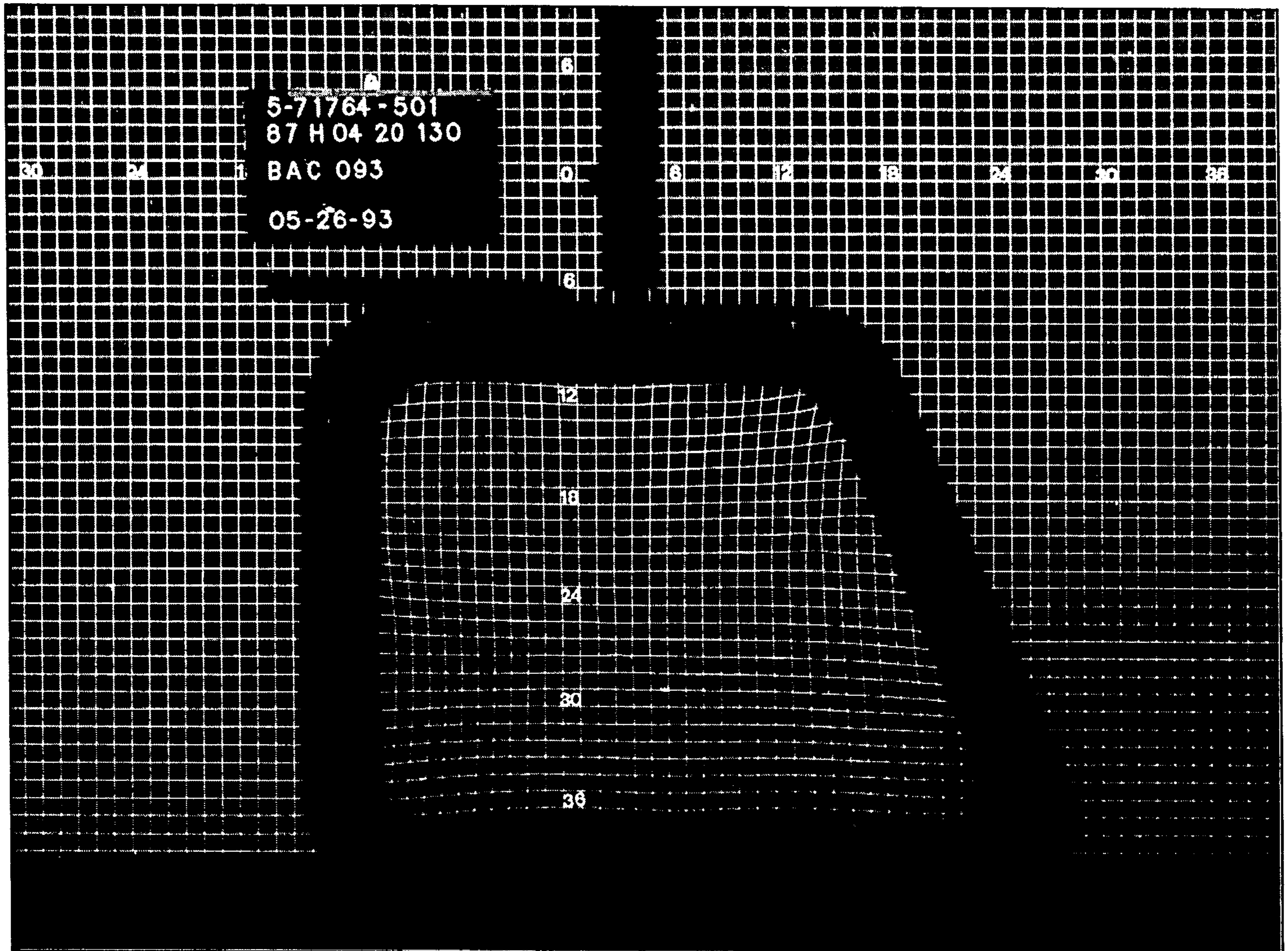


Figure 4.4 Worst Optical Distortion Found in Any C/KC-135 #4 W/WS (S/N 87-H-04-20-130)

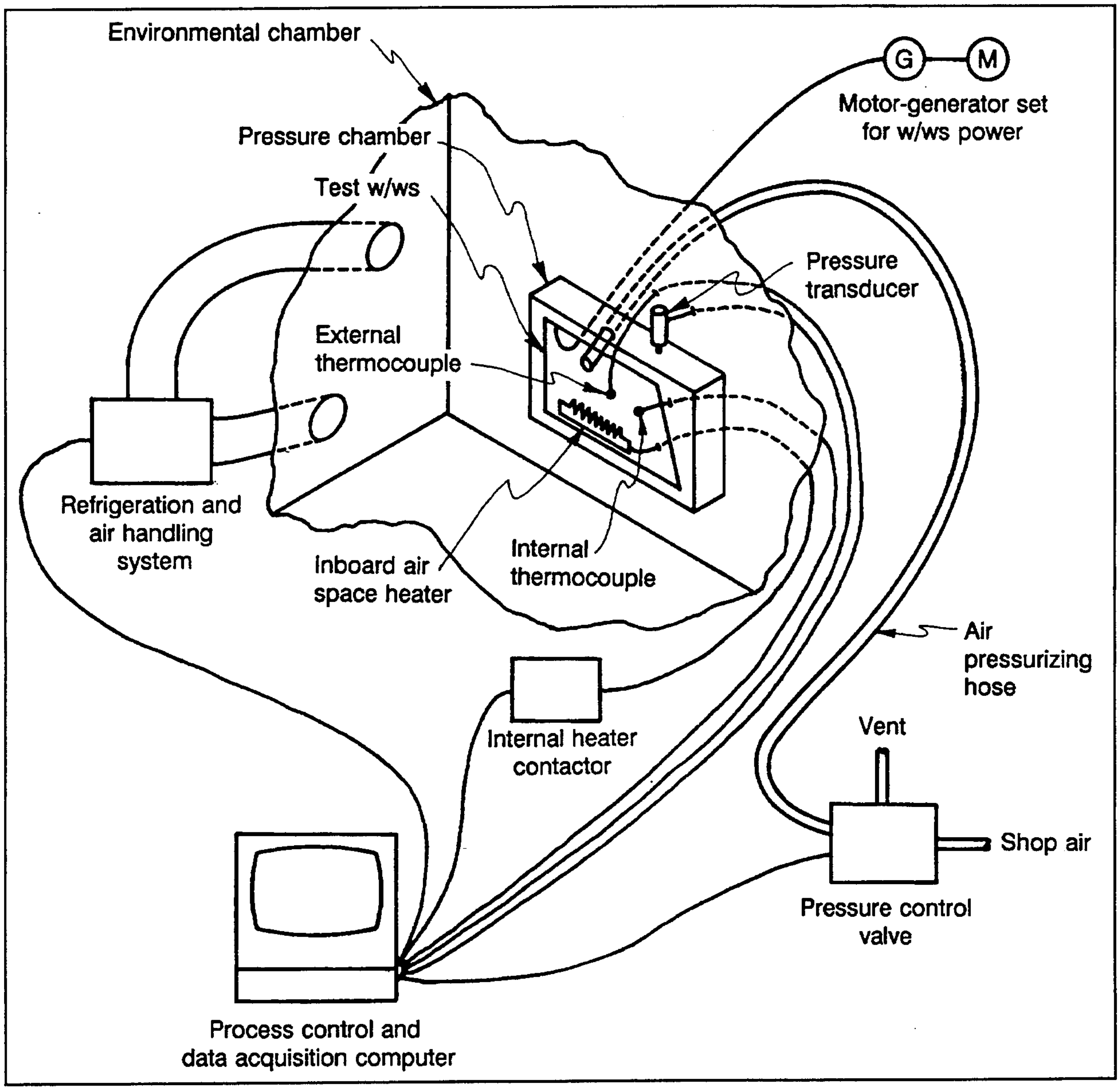


Figure 4.5 Pressure Integrity Testing Facility

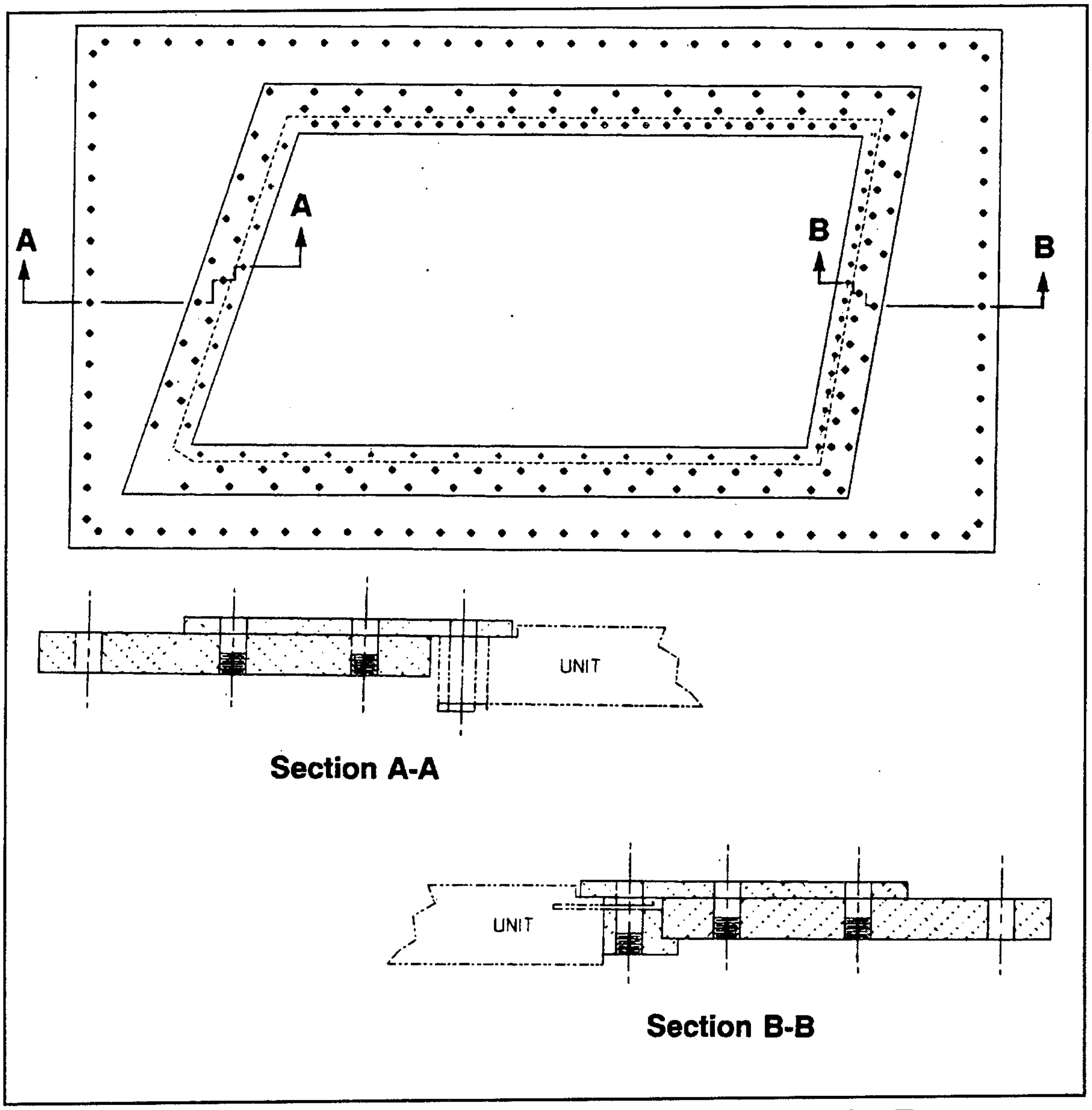


Figure 4.6 C/KC-135 #1 W/WS Pressure Integrity Mounting Frame

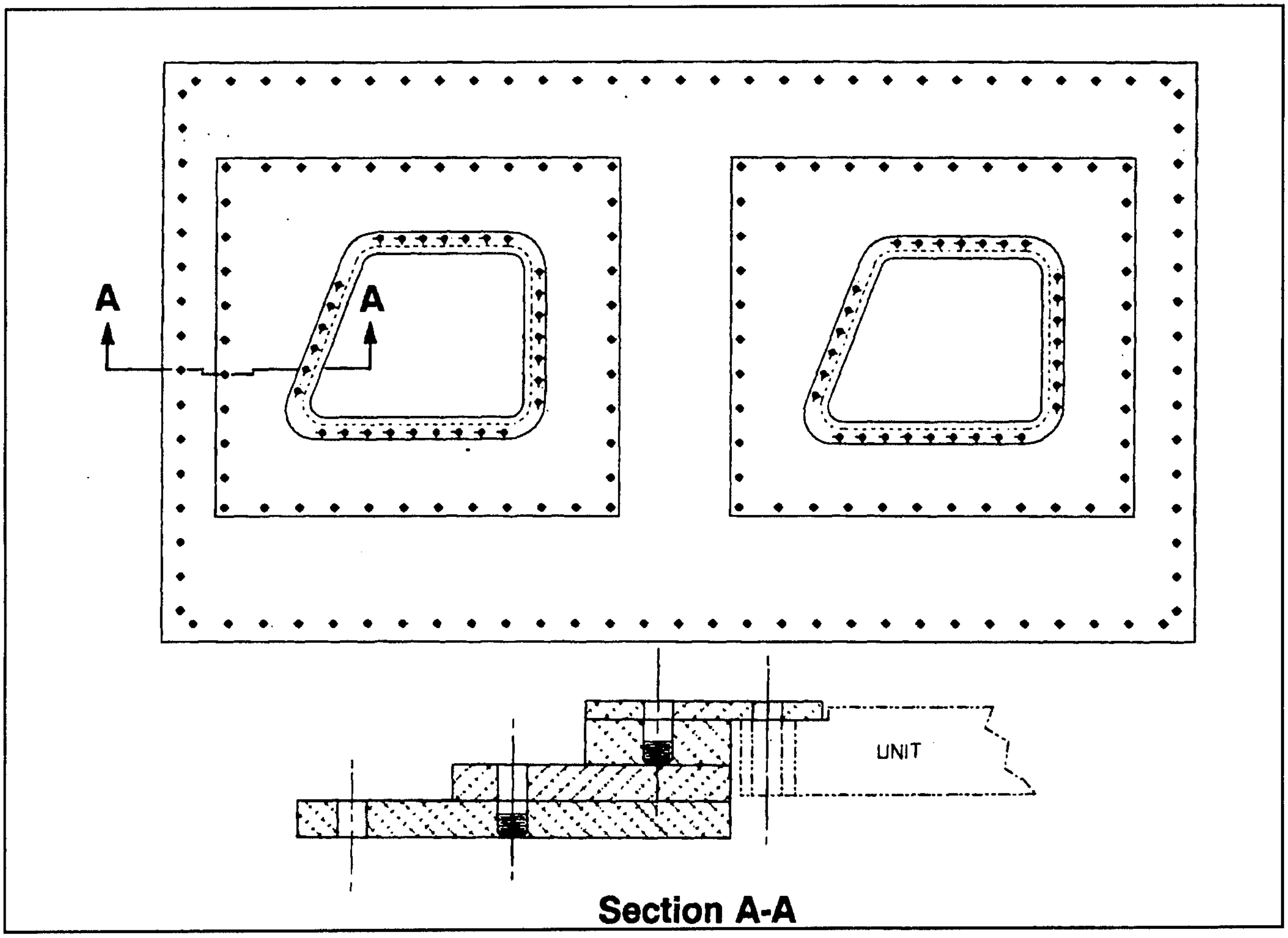
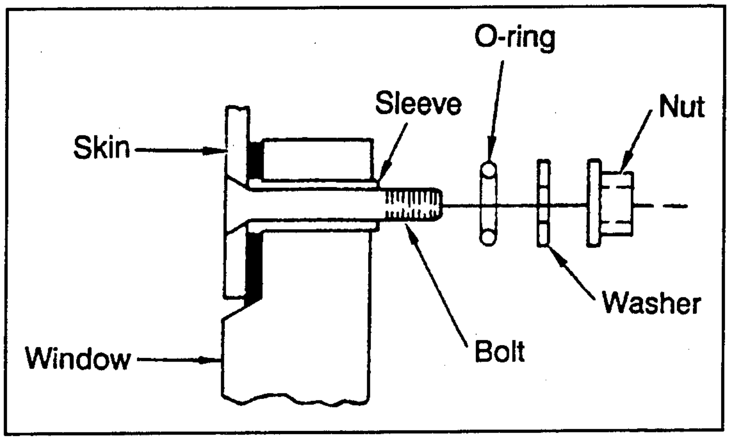
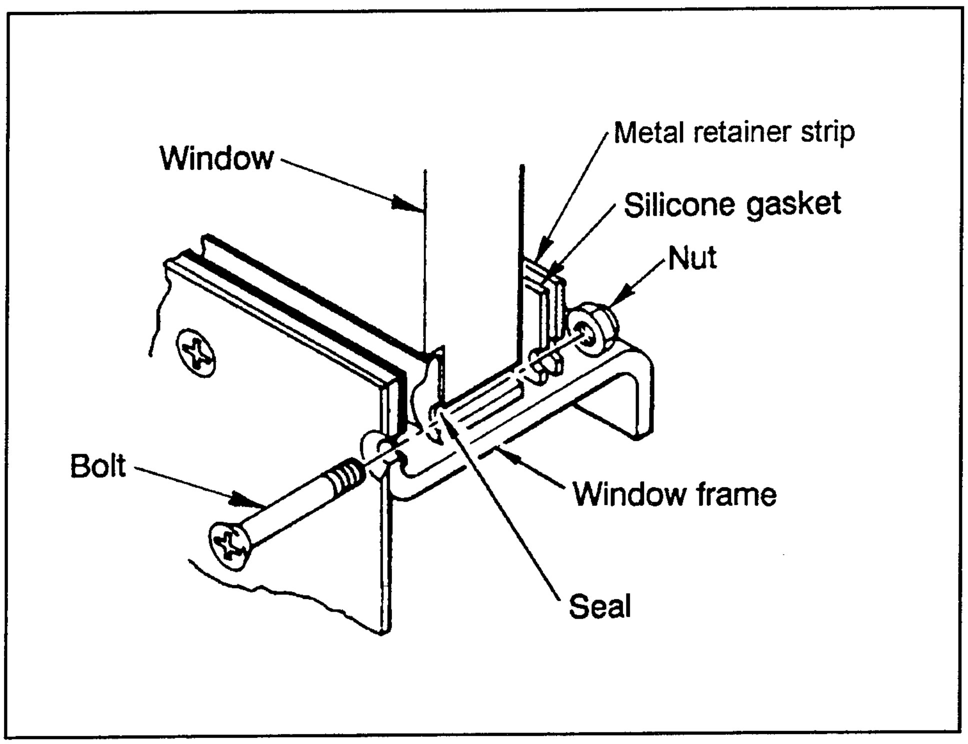


Figure 4.7 C/KC-135 #4 W/WS Pressure Integrity Mounting Frame



a) #1 W/WS



b) #4 W/WS

Figure 4.8 C/KC-135 W/WS Mounting Details

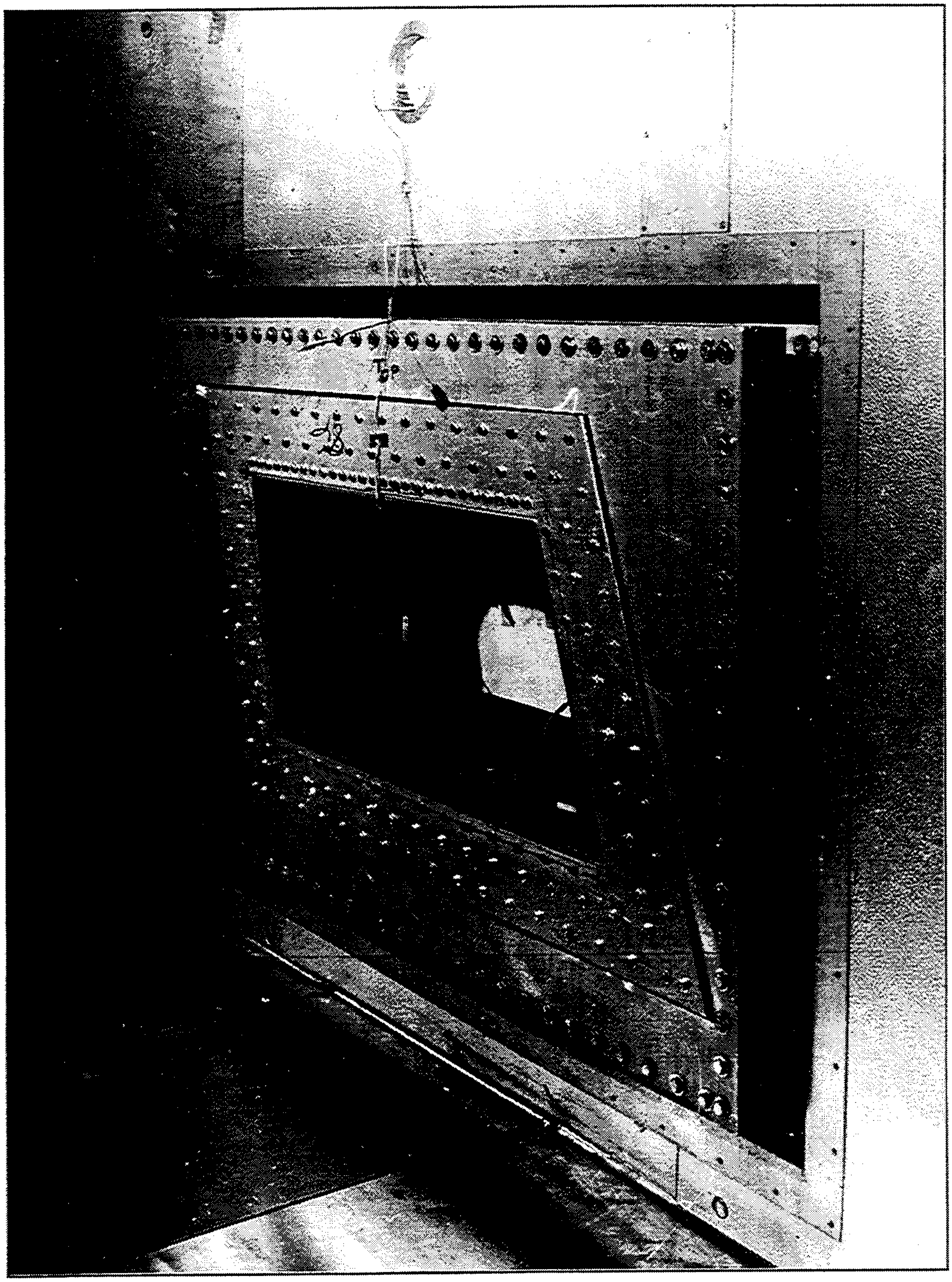


Figure 4.9 Typical C/KC-135 #1 W/WS Pressure Integrity Test Set Up

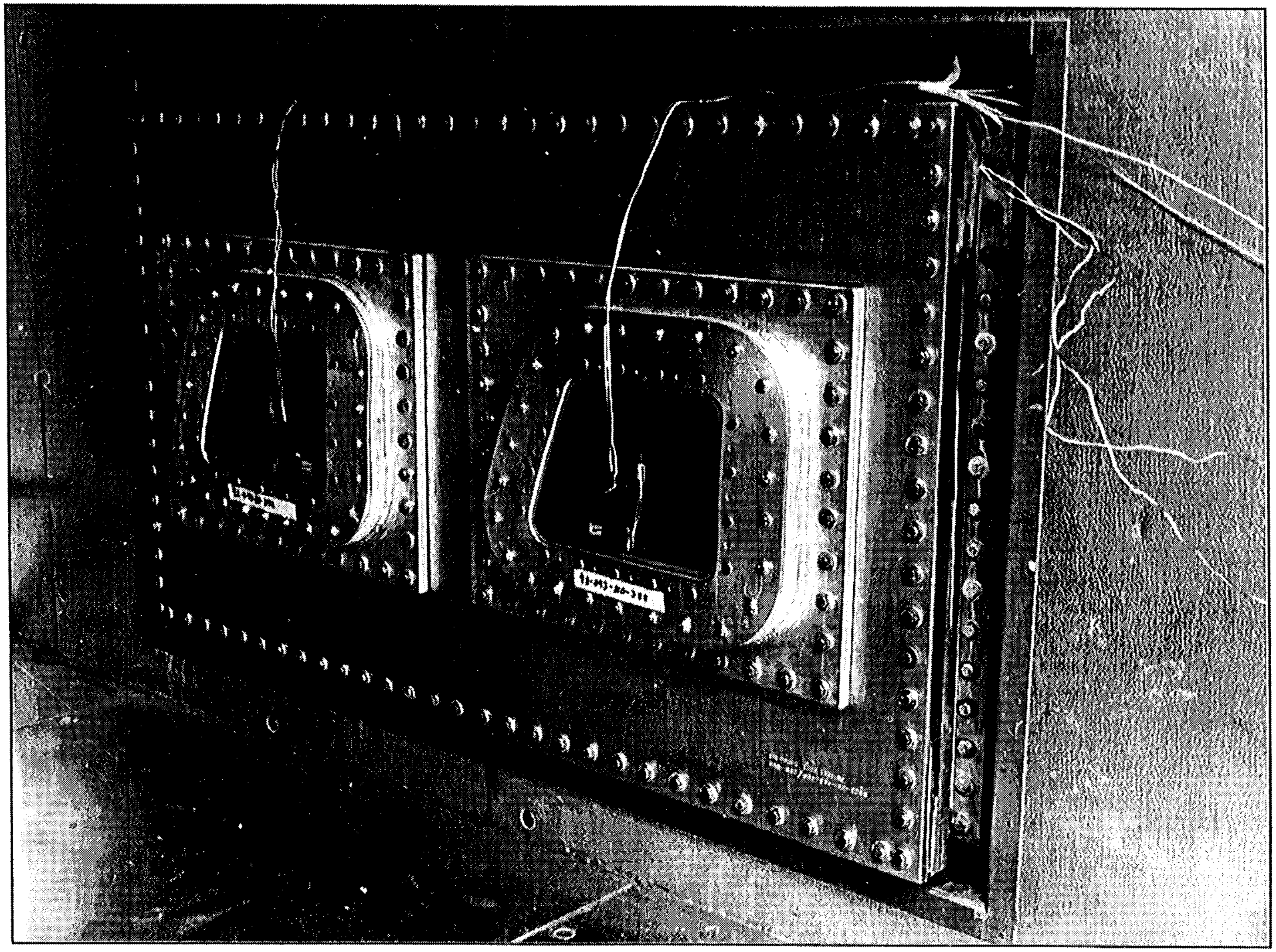


Figure 4.10 Typical C/KC-135 #4 W/WS Pressure Integrity Test Set Up

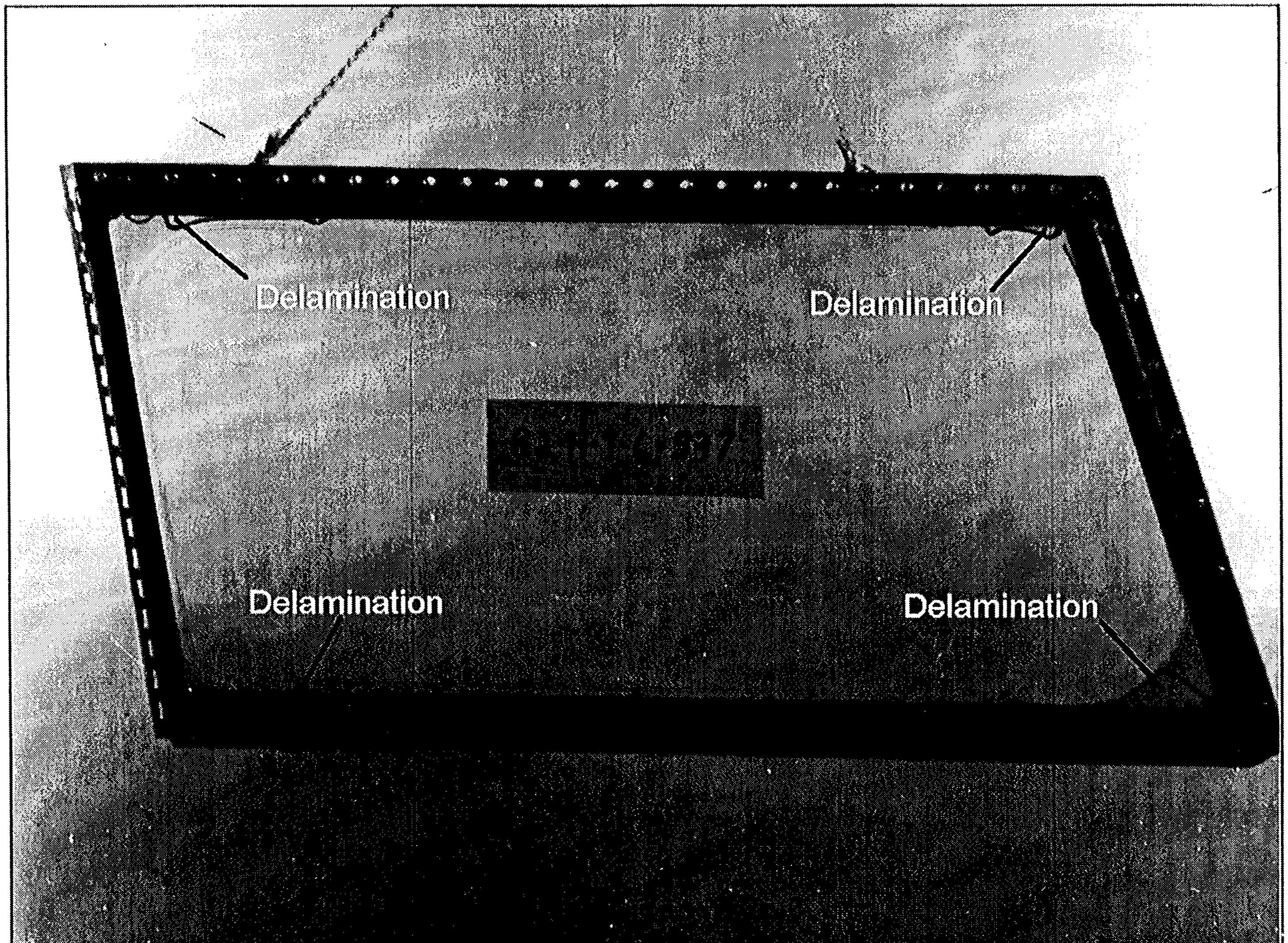


Figure 4.11 Worst Delamination Observed in a C/KC-135 #1 W/WS From Pressure Cycling (Repaired W/WS, S/N 82-H-09-06-537)

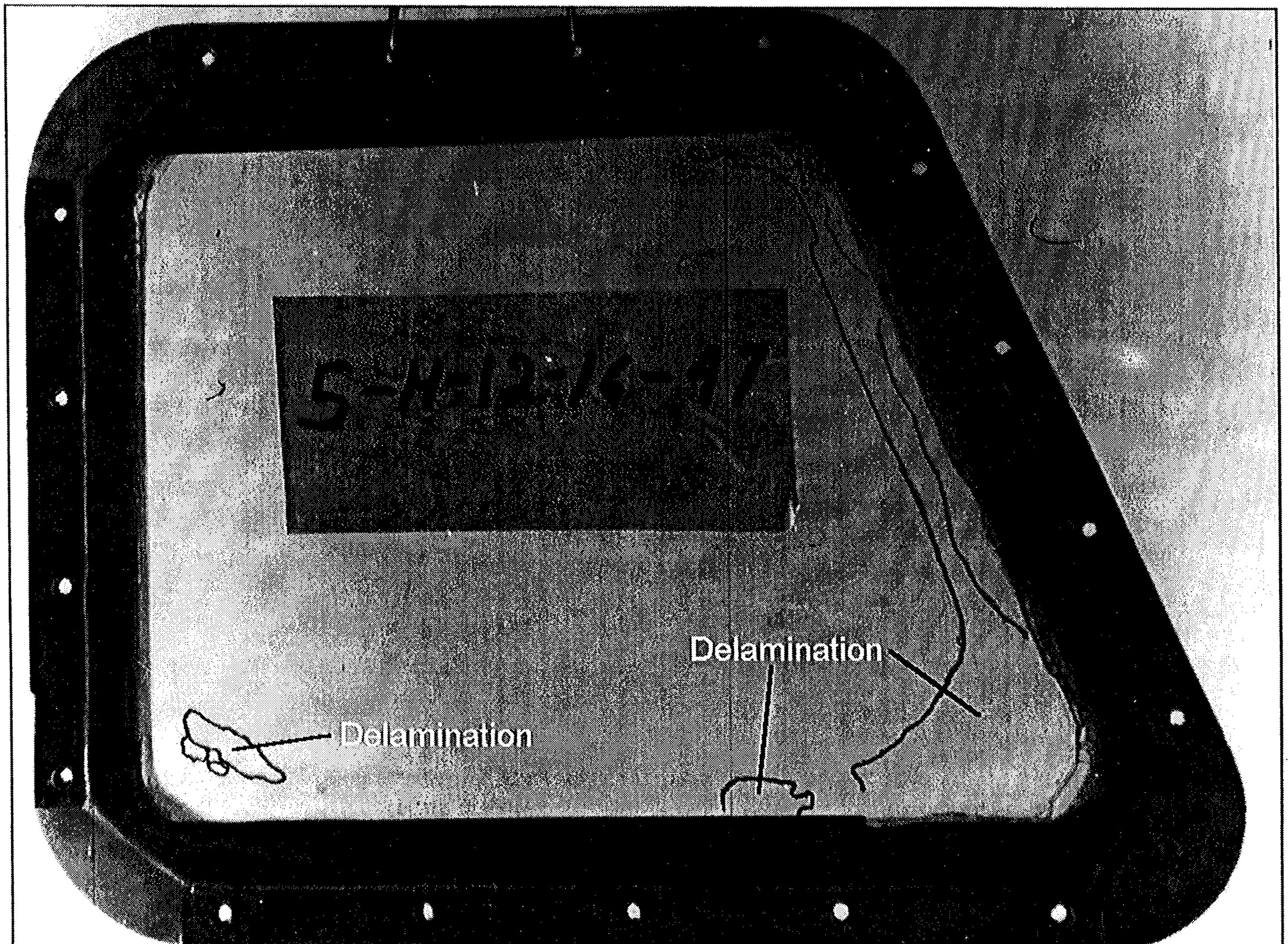


Figure 4.12 Worst Delamination Observed in a C/KC-135 #4 W/WS From Pressure Cycling (Repaired W/WS, S/N 5-H-12-16-47)

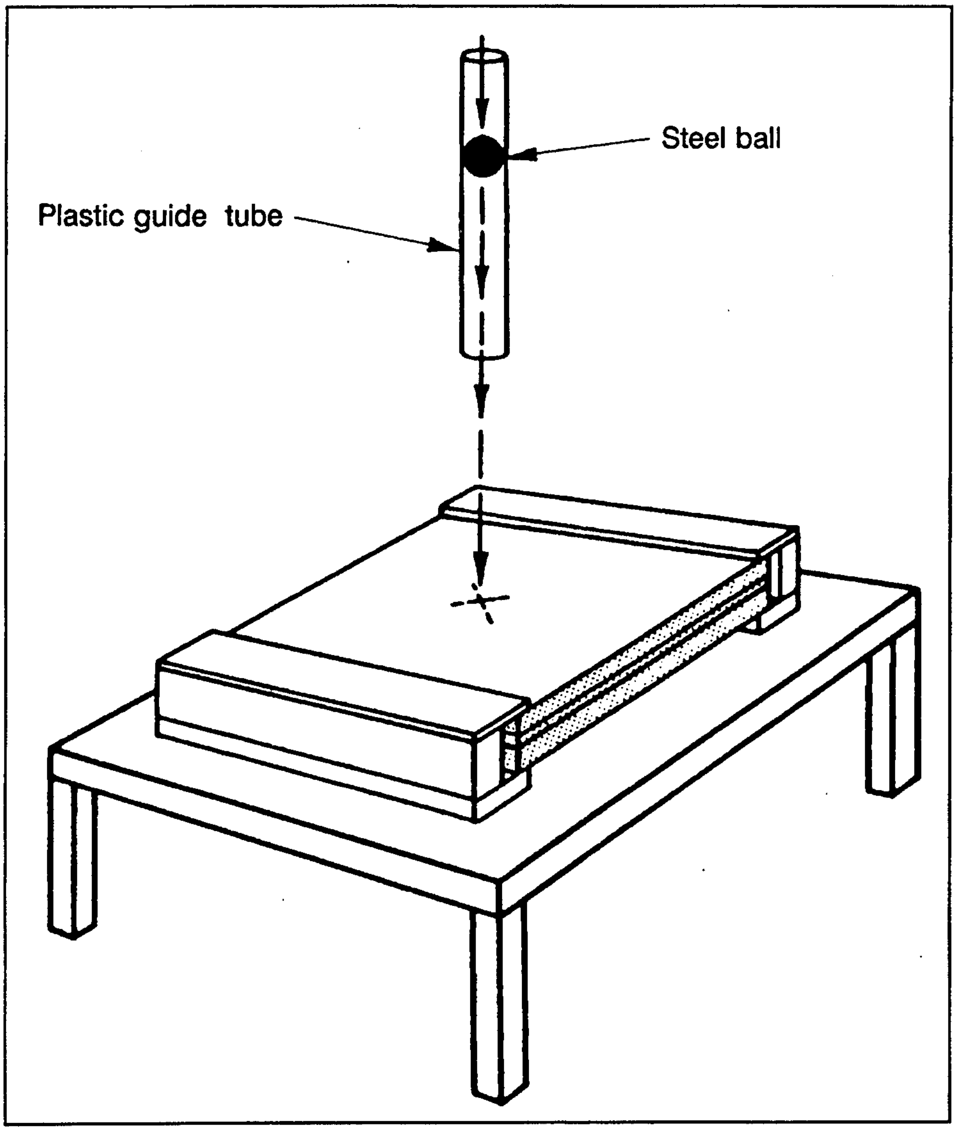


Figure 4.13 Residual Strength Falling Ball Test

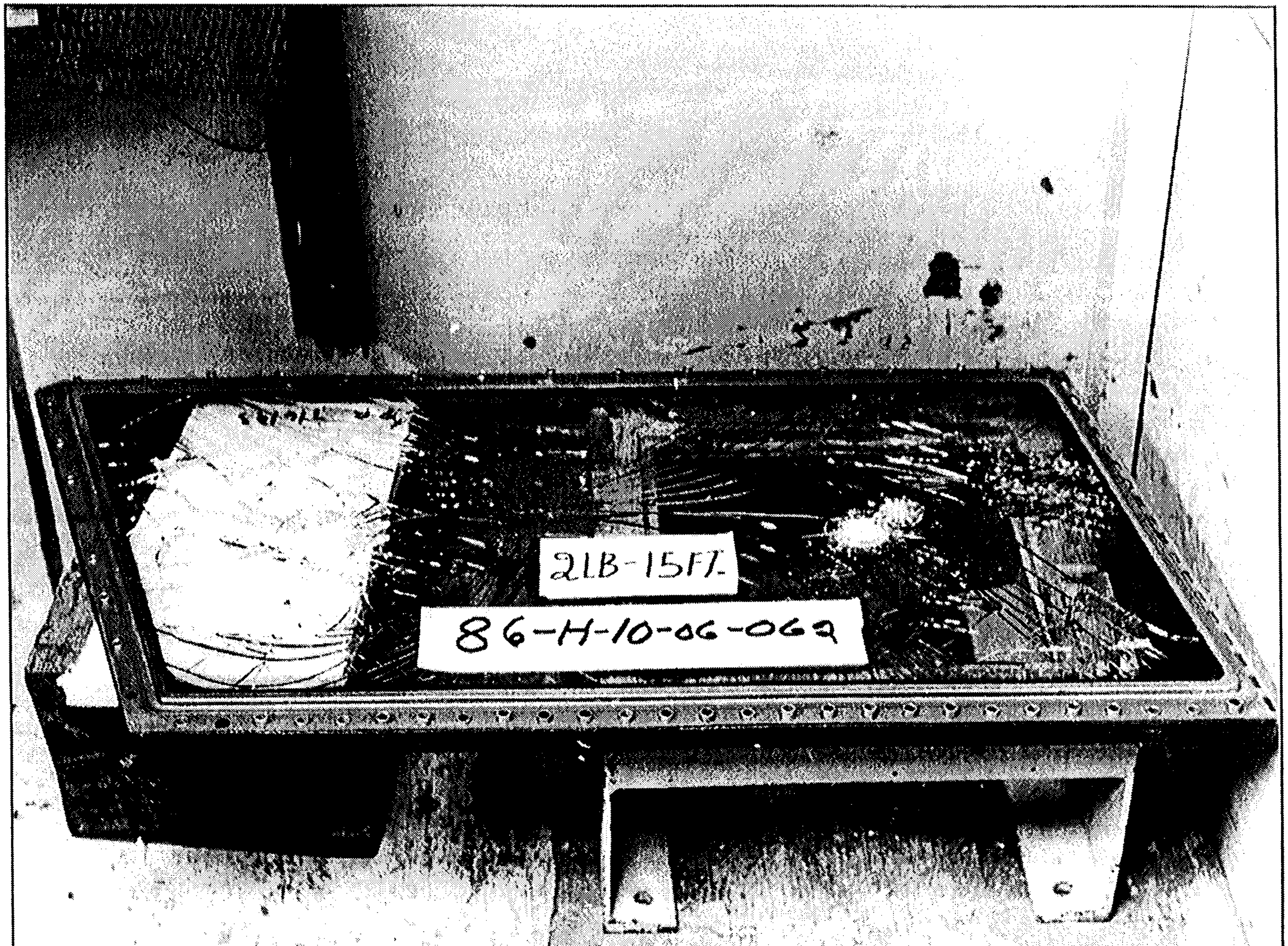


Figure 4.14 #1 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Consequences of Two Ball Drops (New W/WS, S/N 86-H-10-06-062)

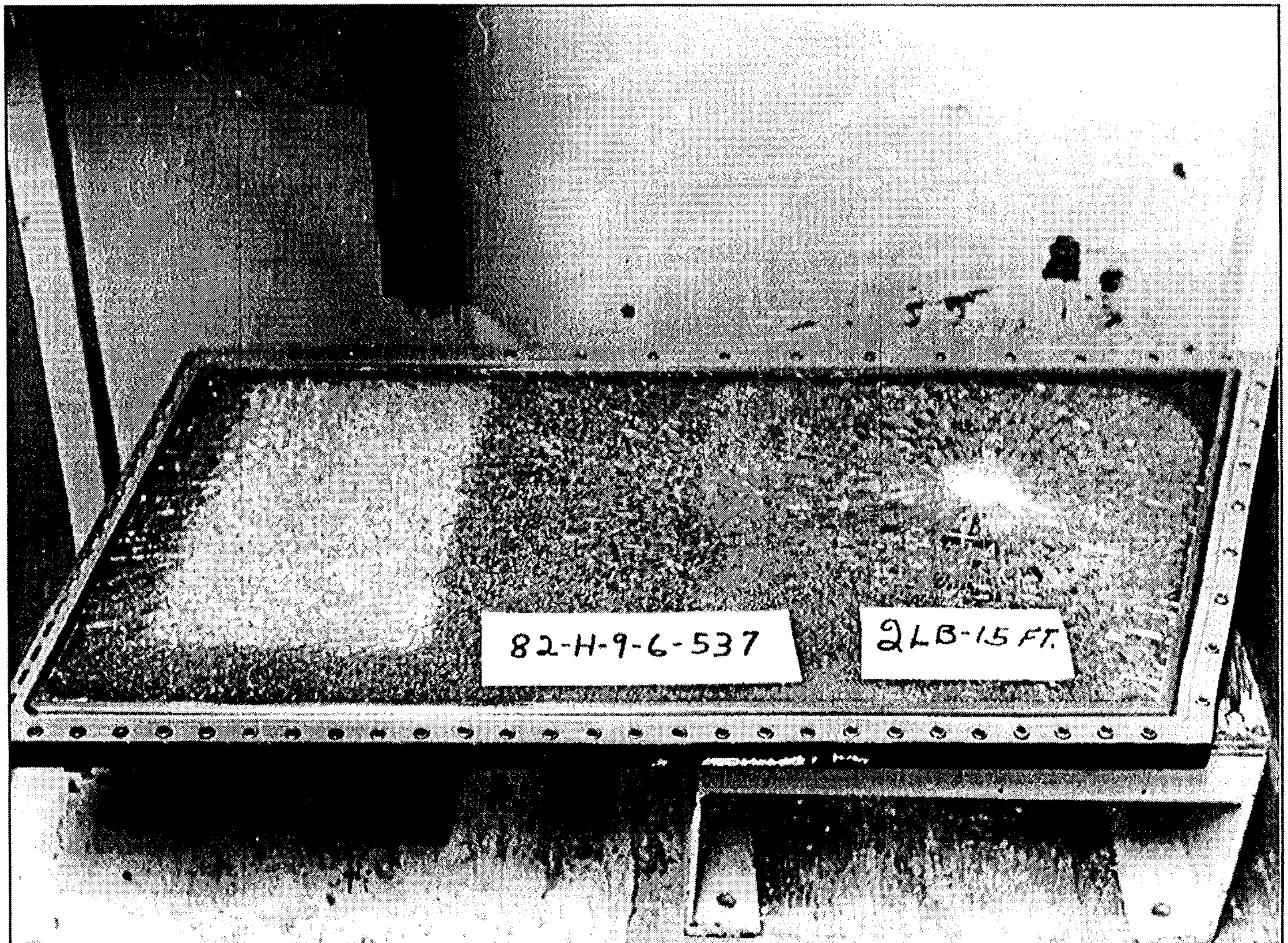


Figure 4.15 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Outboard View (S/N 82-H-9-6-537)

Figure 4.16 #1 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Single Ball Drop, Inboard View (S/N 82-H-9-6-537)

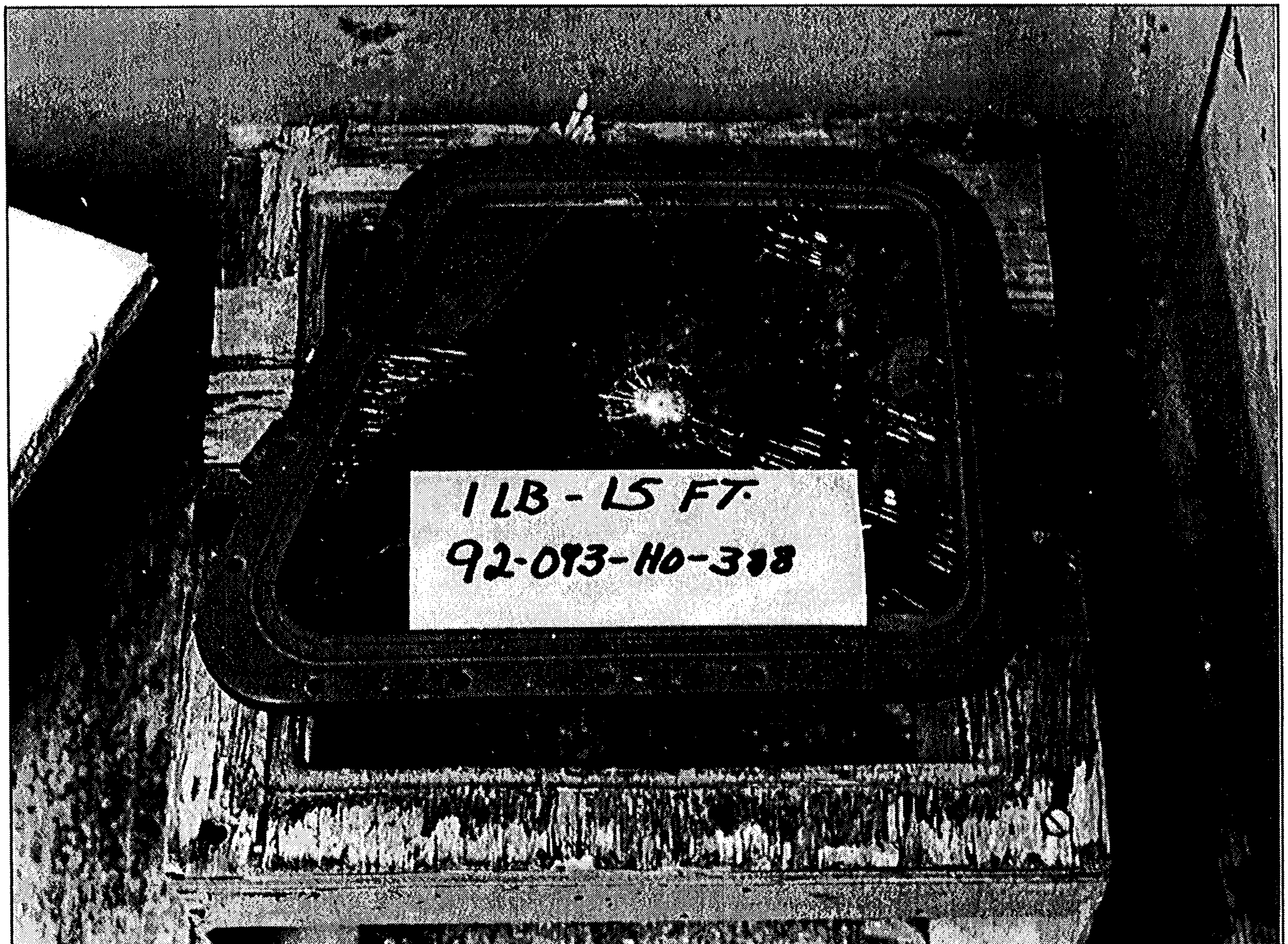


Figure 4.17 #4 W/WS Residual Strength Falling Ball Impact Test Showing Test Set Up and Test Result (New W/WS, S/N 92-093-HO-388)

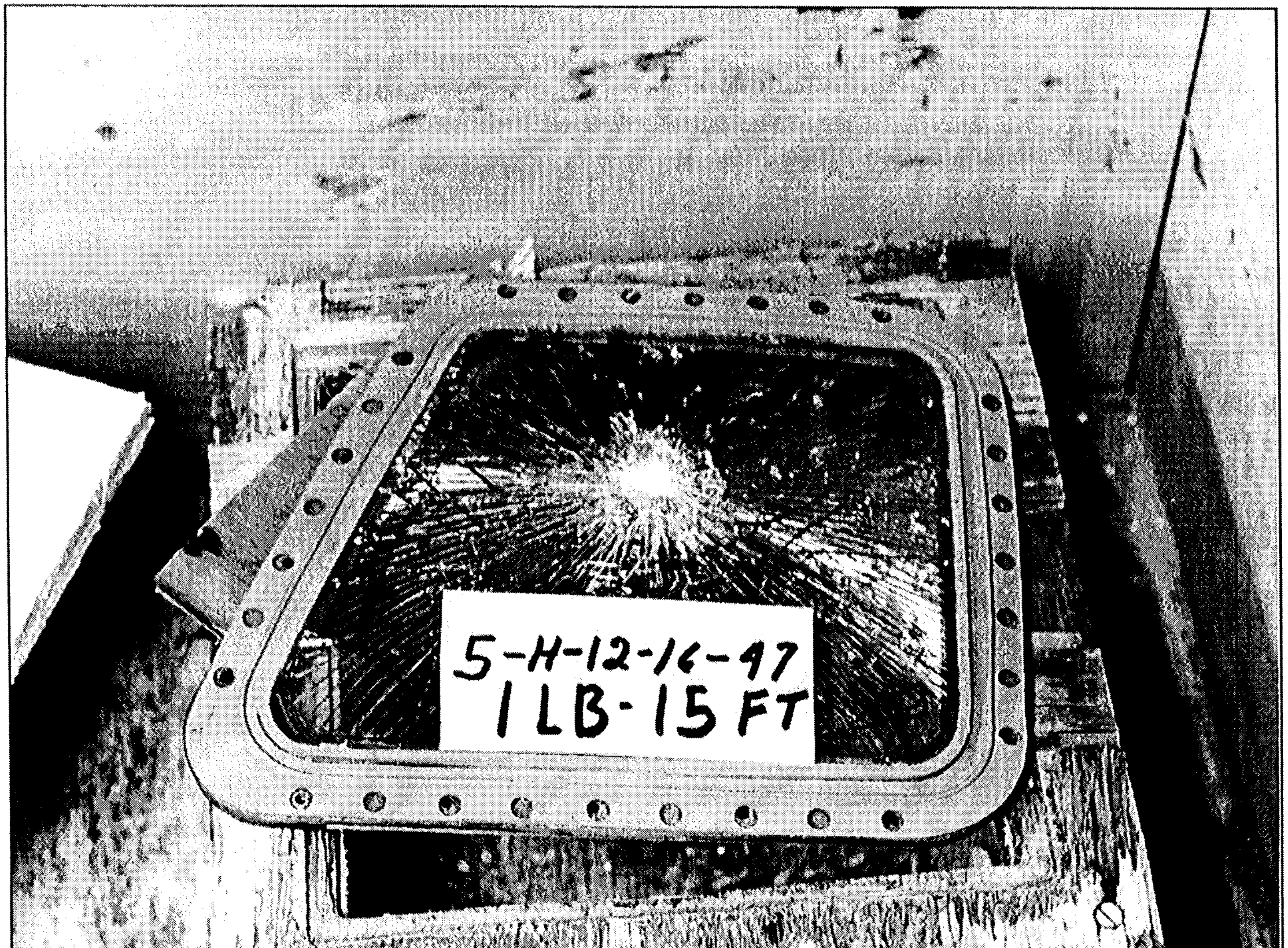


Figure 4.18 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Outboard View (S/N 5-H-12-16-47)

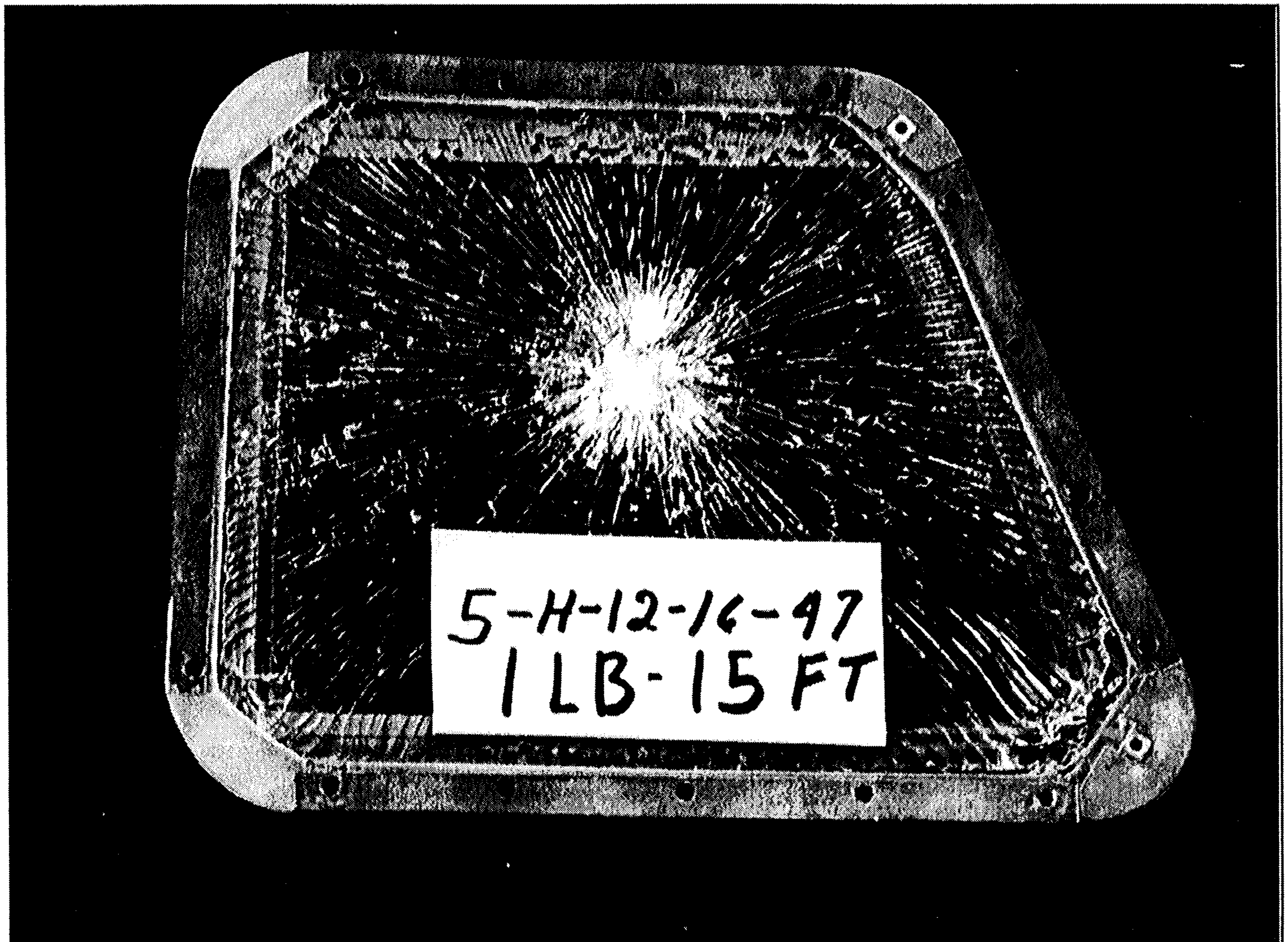


Figure 4.19 #4 W/WS Residual Strength Falling Ball Impact Test Result for a Repaired and Subsequently Delaminated W/WS, Inboard View (S/N 5-H-12-16-47)

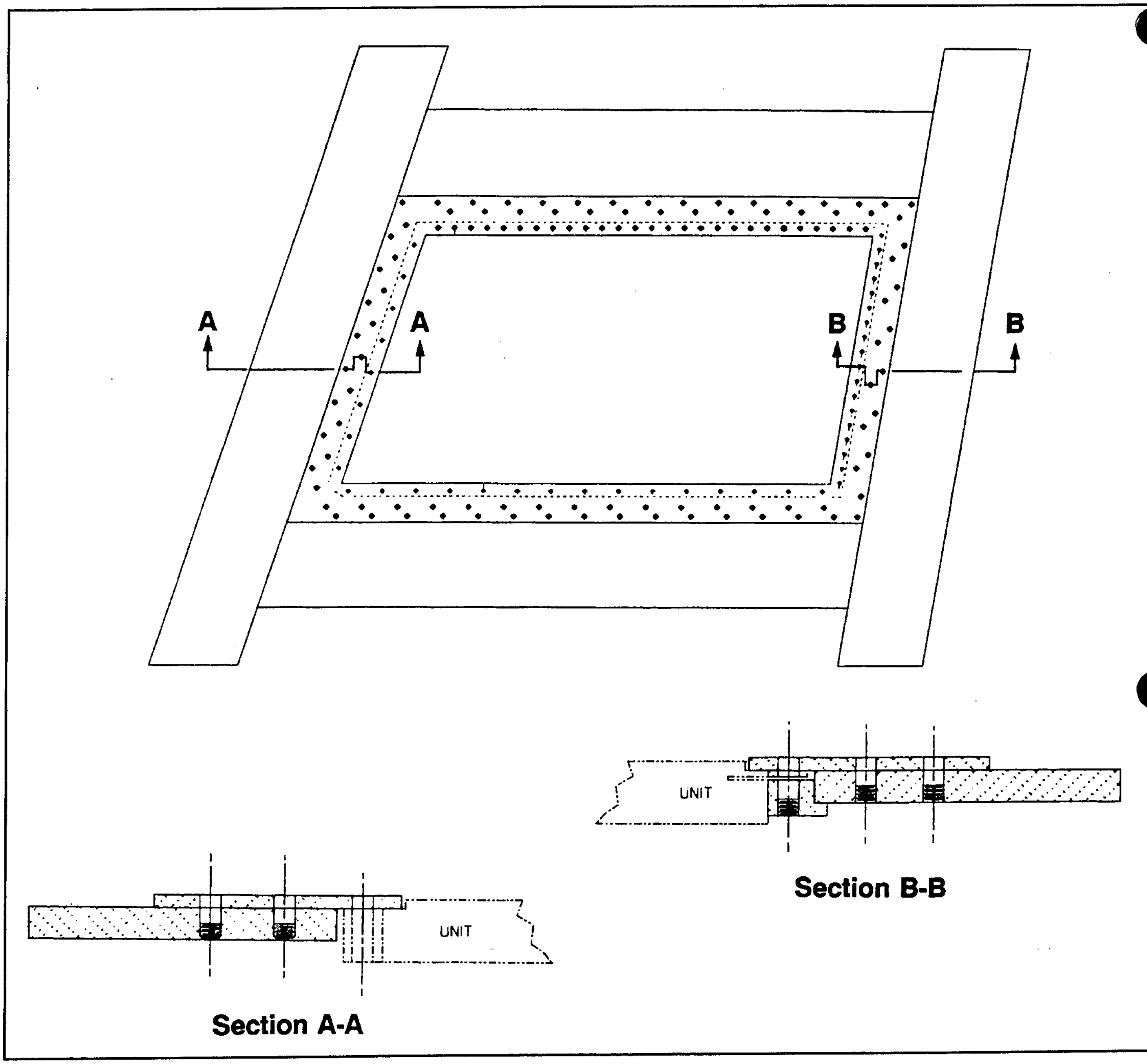


Figure 4.20 C/KC-135 #1 W/WS Bird Impact Mounting Frame

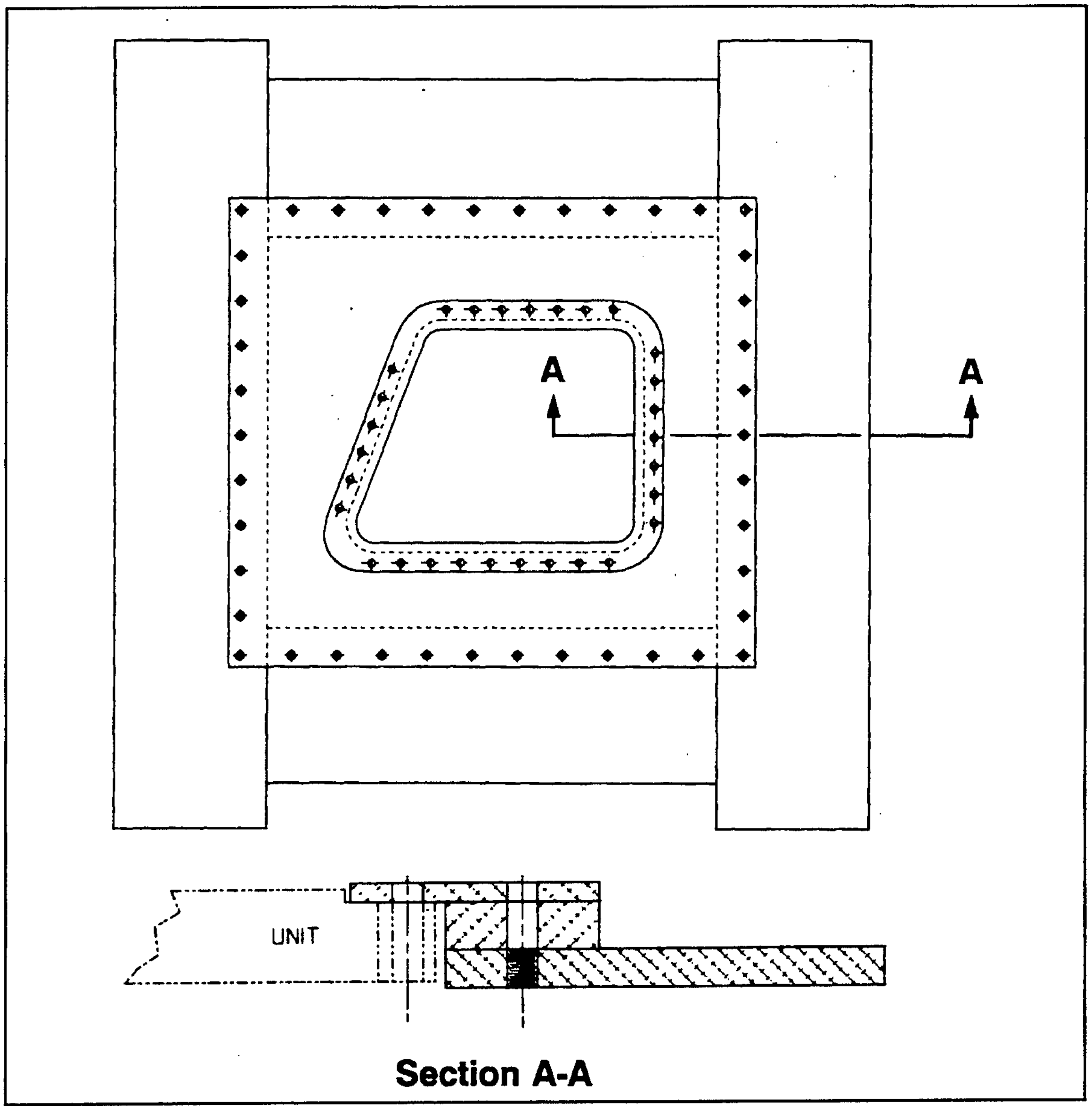


Figure 4.21 C/KC-135 #4 W/WS Bird Impact Mounting Frame

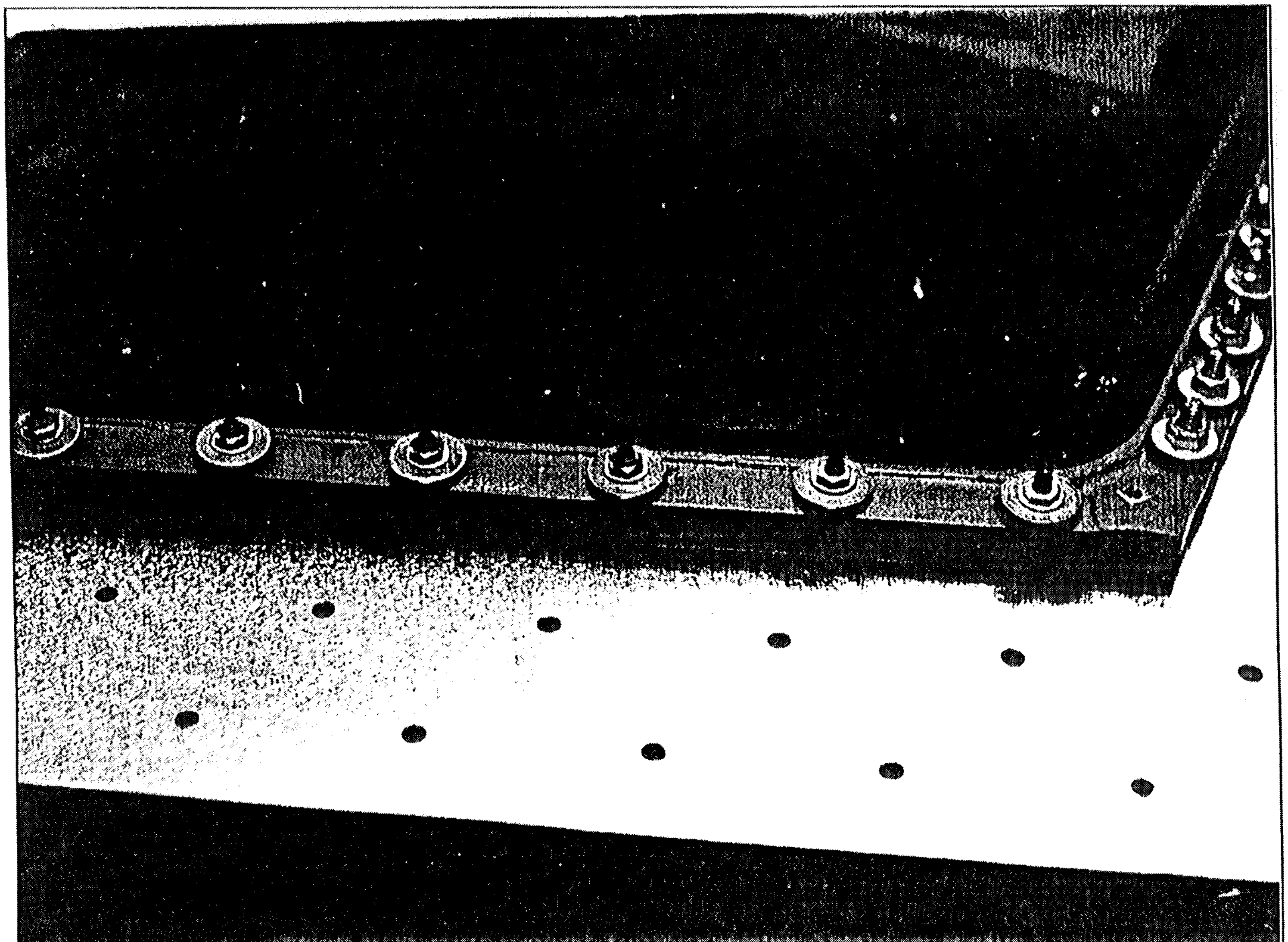


Figure 4.22 C/KC-135 #1 W/WS Mounting Hardware Details

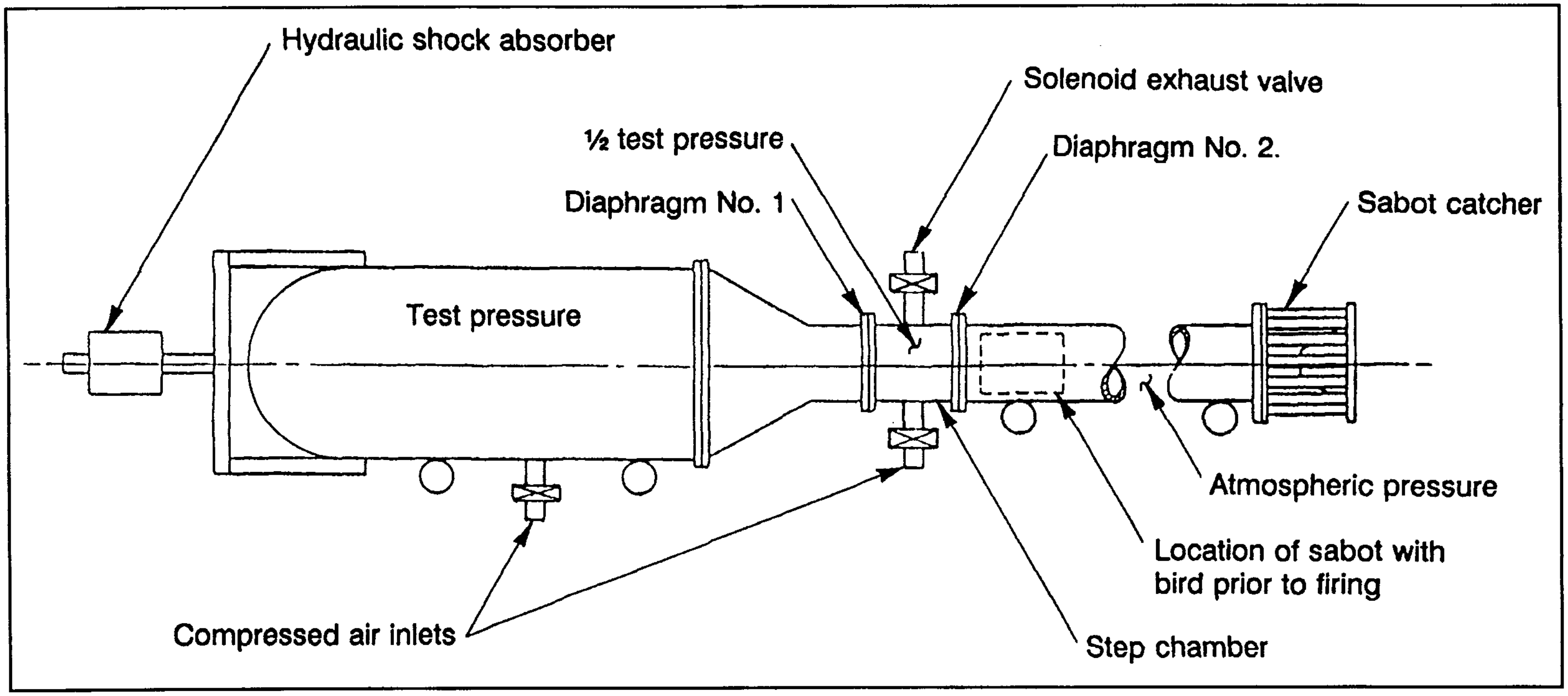


Figure 4.23 Schematic of the PPG Bird Cannon

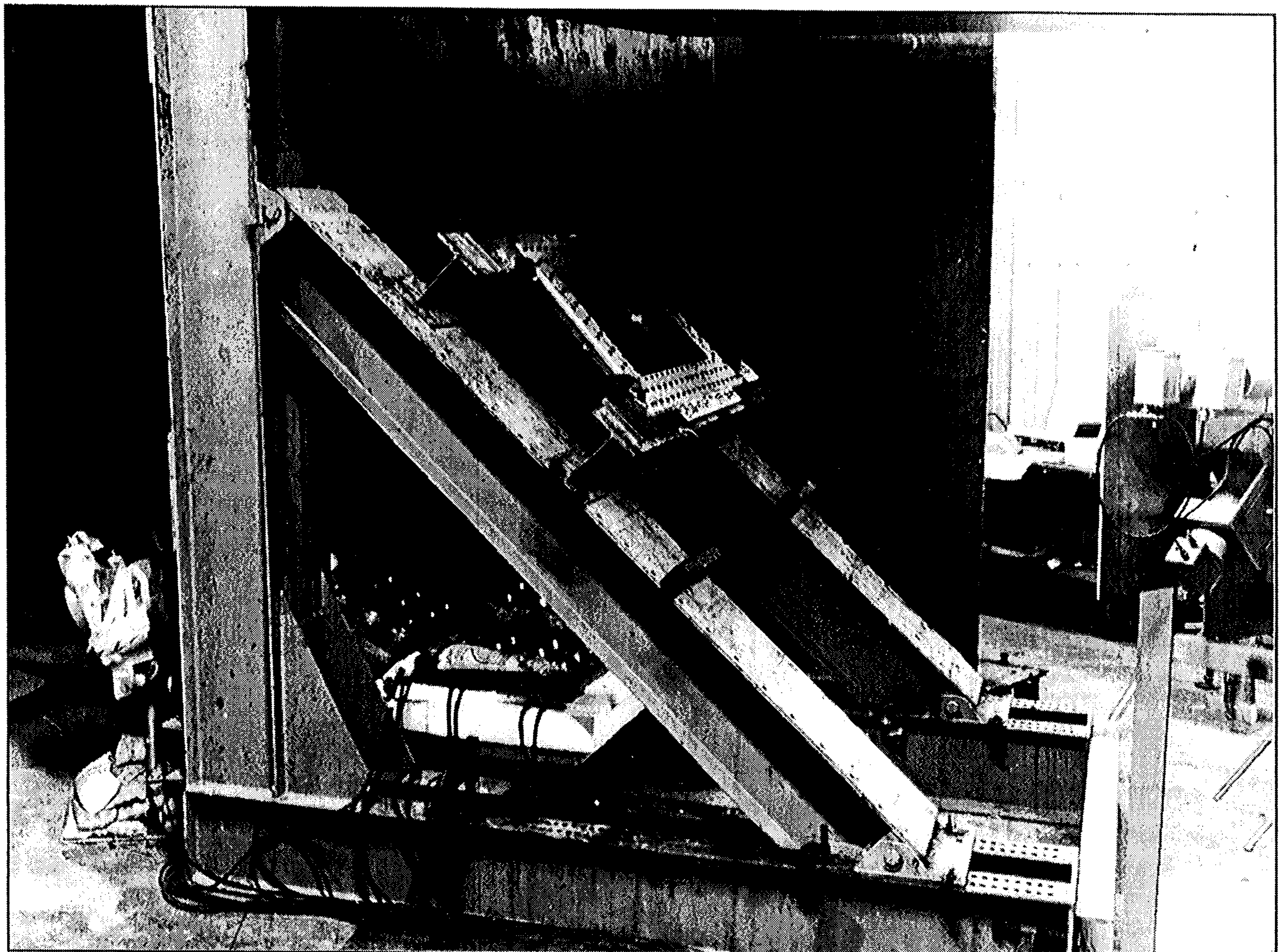


Figure 4.24 Support Frame Used for Bird Impact Testing for C/KC-135 W/WS

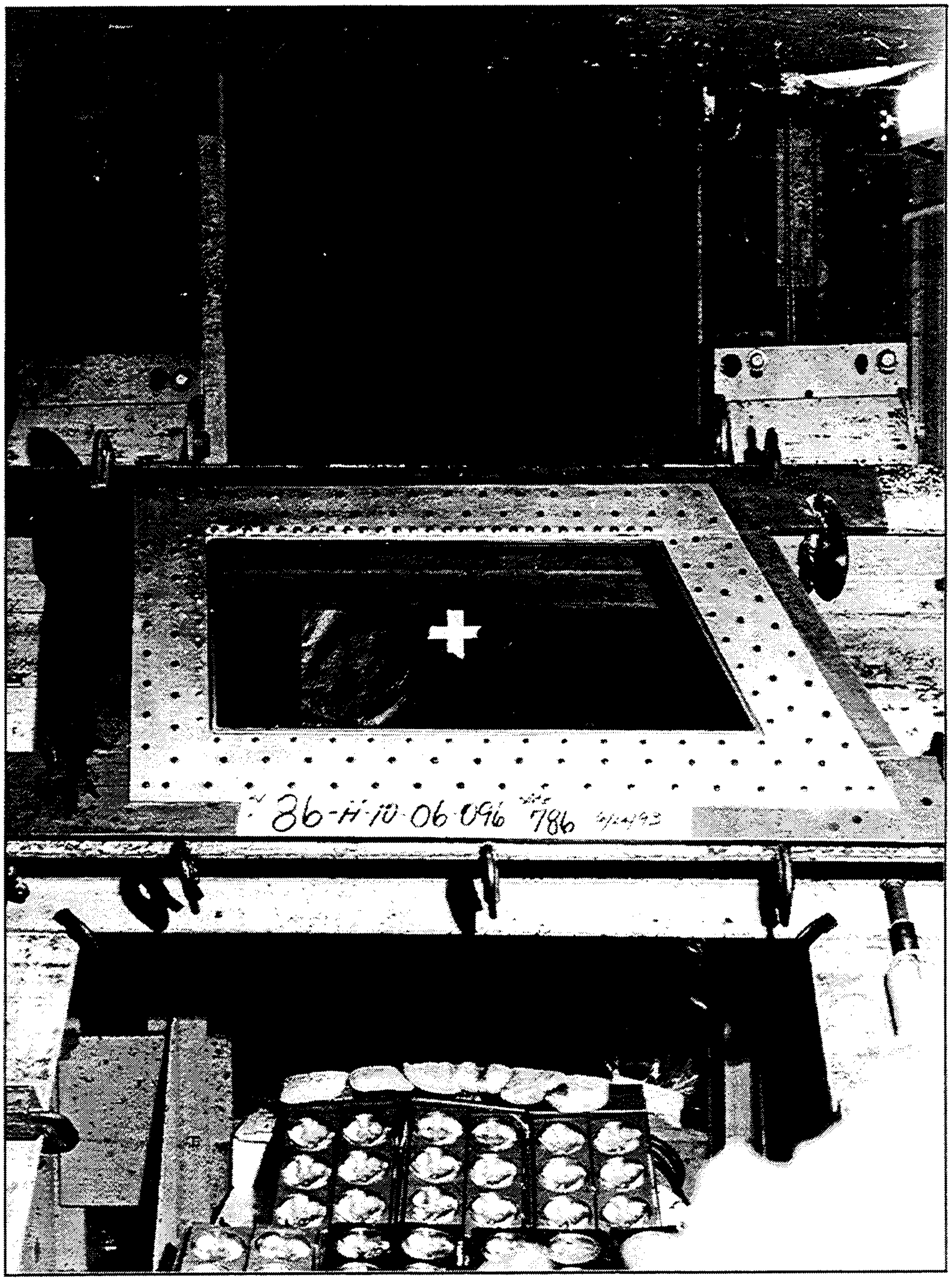


Figure 4.25 Typical Pre-Test View of C/KC-135 #1 W/WS (Copilot) Prior to Bird Impact Testing

Figure 4.26 Typical Pre-Test View of C/KC-135 #4 W/WS (Pilot) Prior to Bird Impact Testing

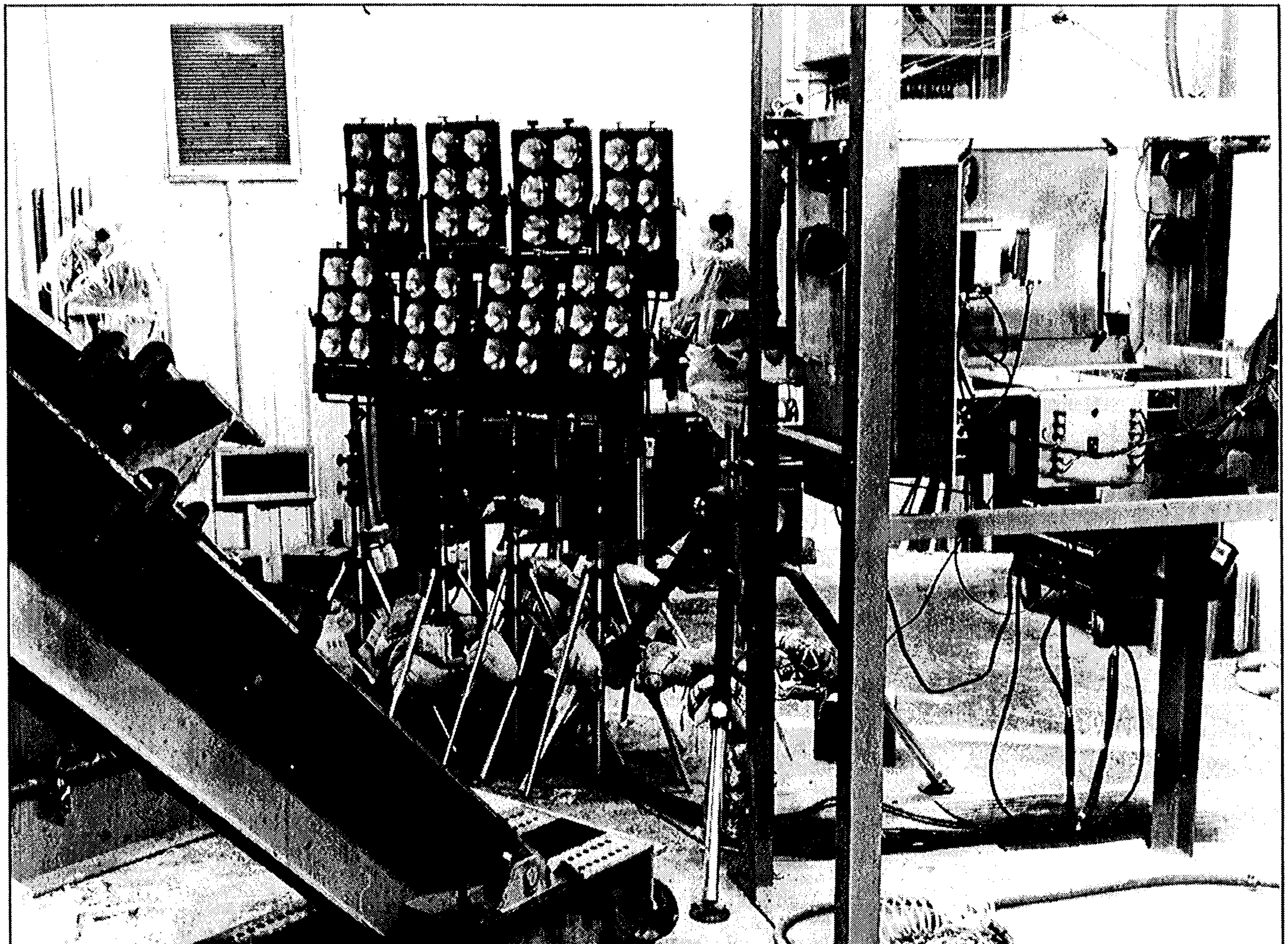


Figure 4.27 Bird Impact Test Set Up Showing Impact Velocity Timing Trap (Right) and Front High Speed Film Camera Equipment (Center)

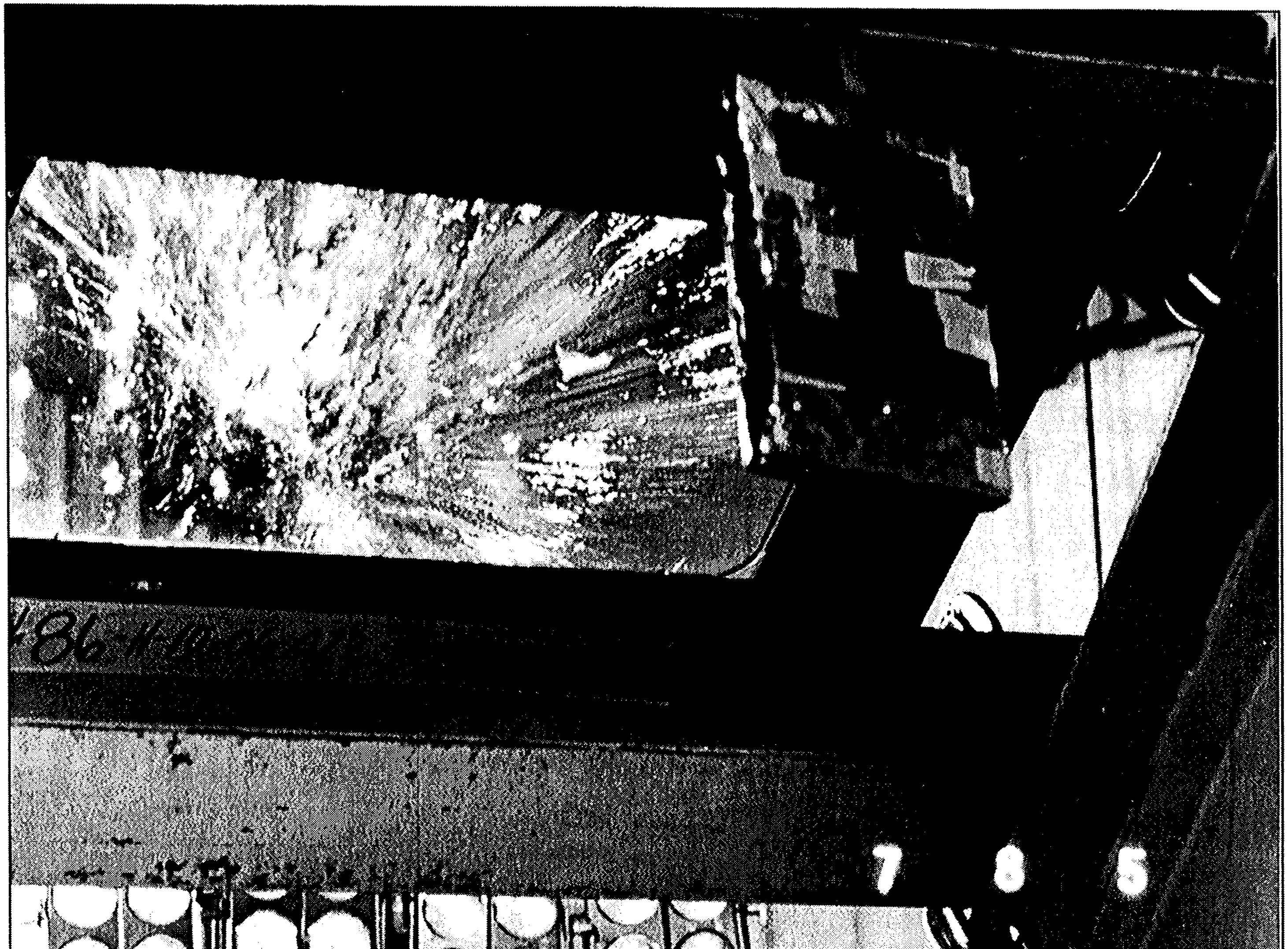


Figure 4.28 Bird Impact Spall Sheet Viewed From Behind a C/KC-135 #1 W/WS

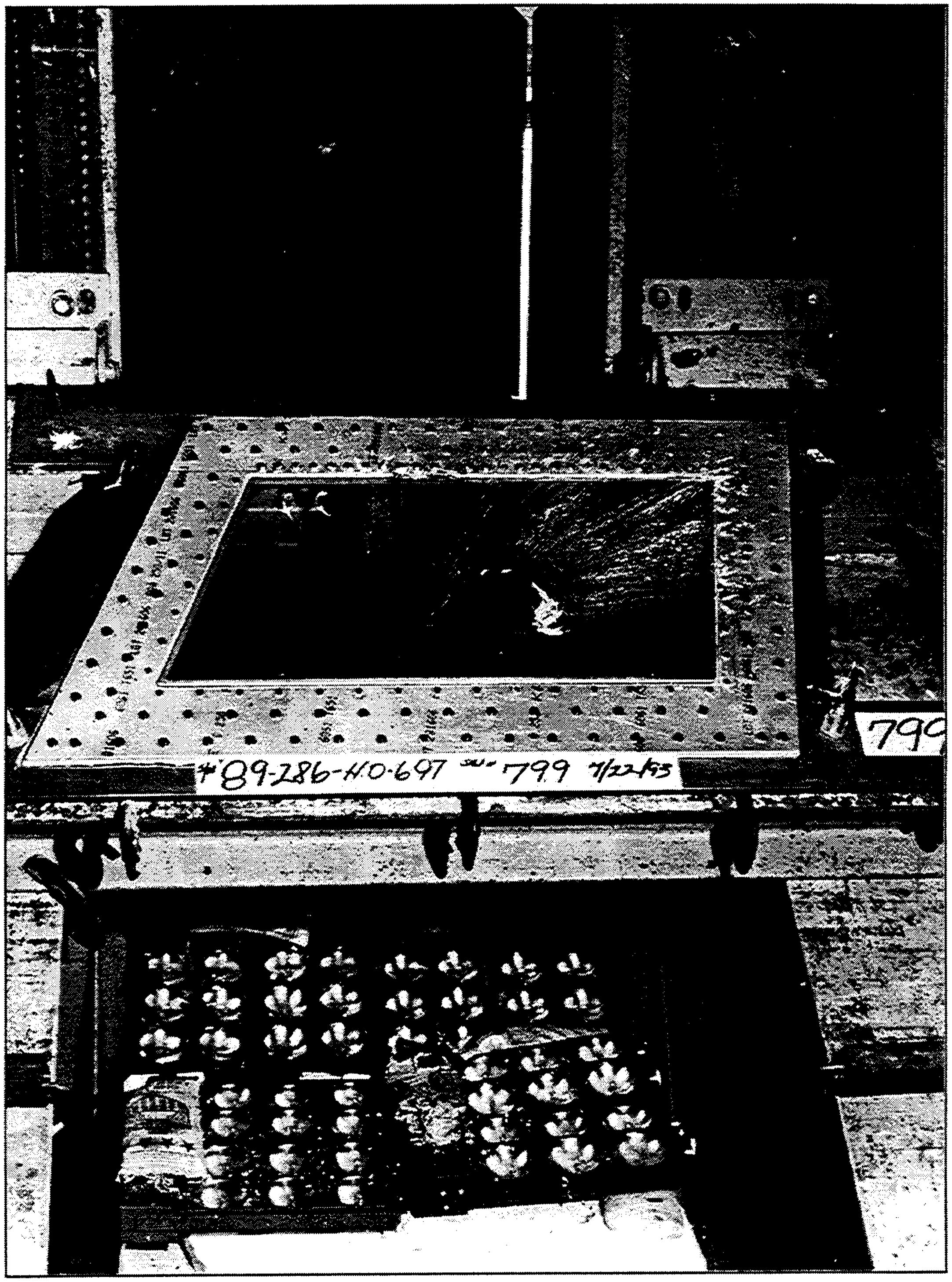


Figure 4.29 C/KC-135 #1 W/WS Showing No Damage From a 4-Pound Bird Impact at 250.8 Knots (Repaired W/WS, S/N 89-286-HO-697)

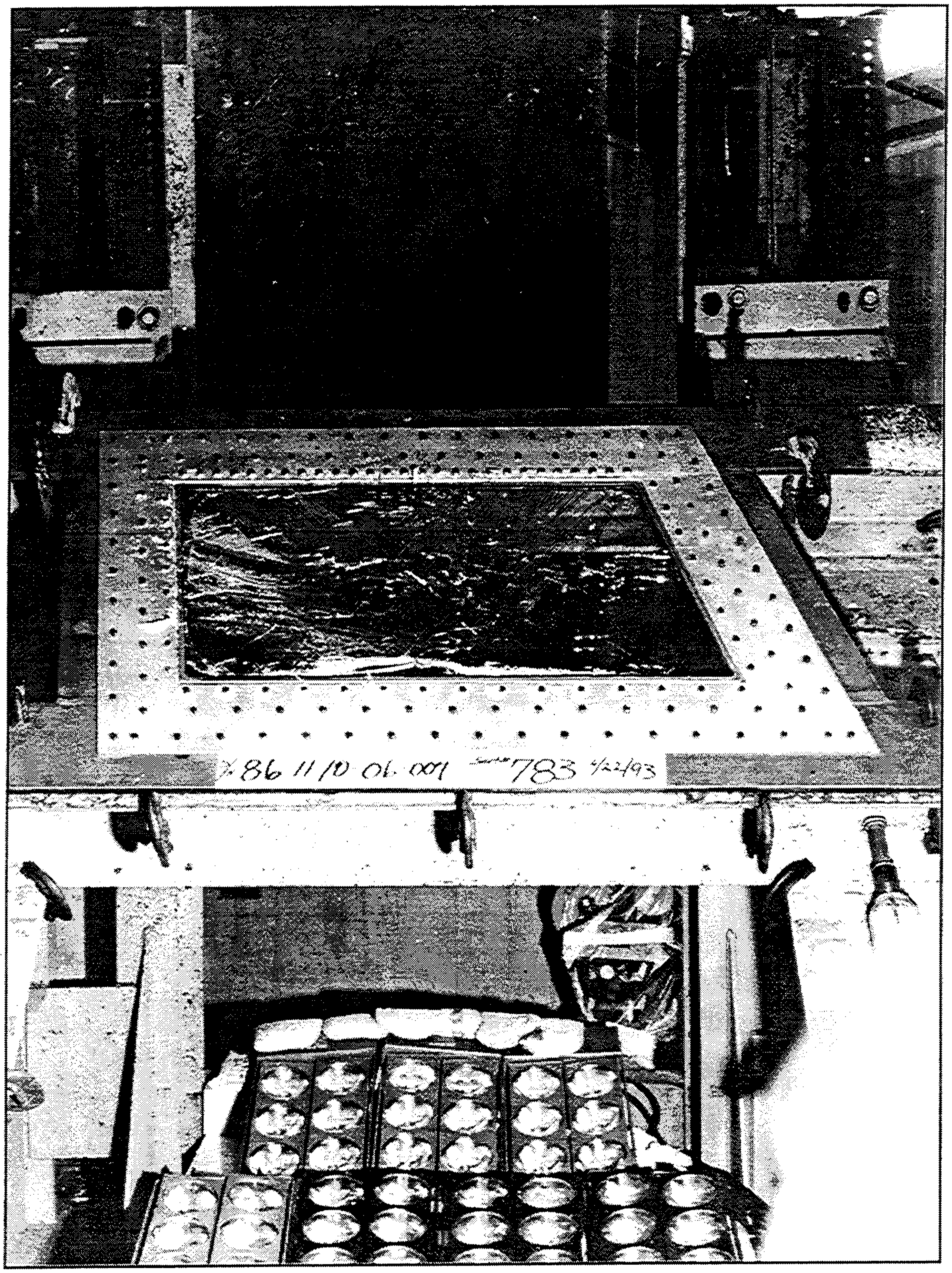


Figure 4.30 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Front View (New W/WS, S/N 86-H-10-06-007)

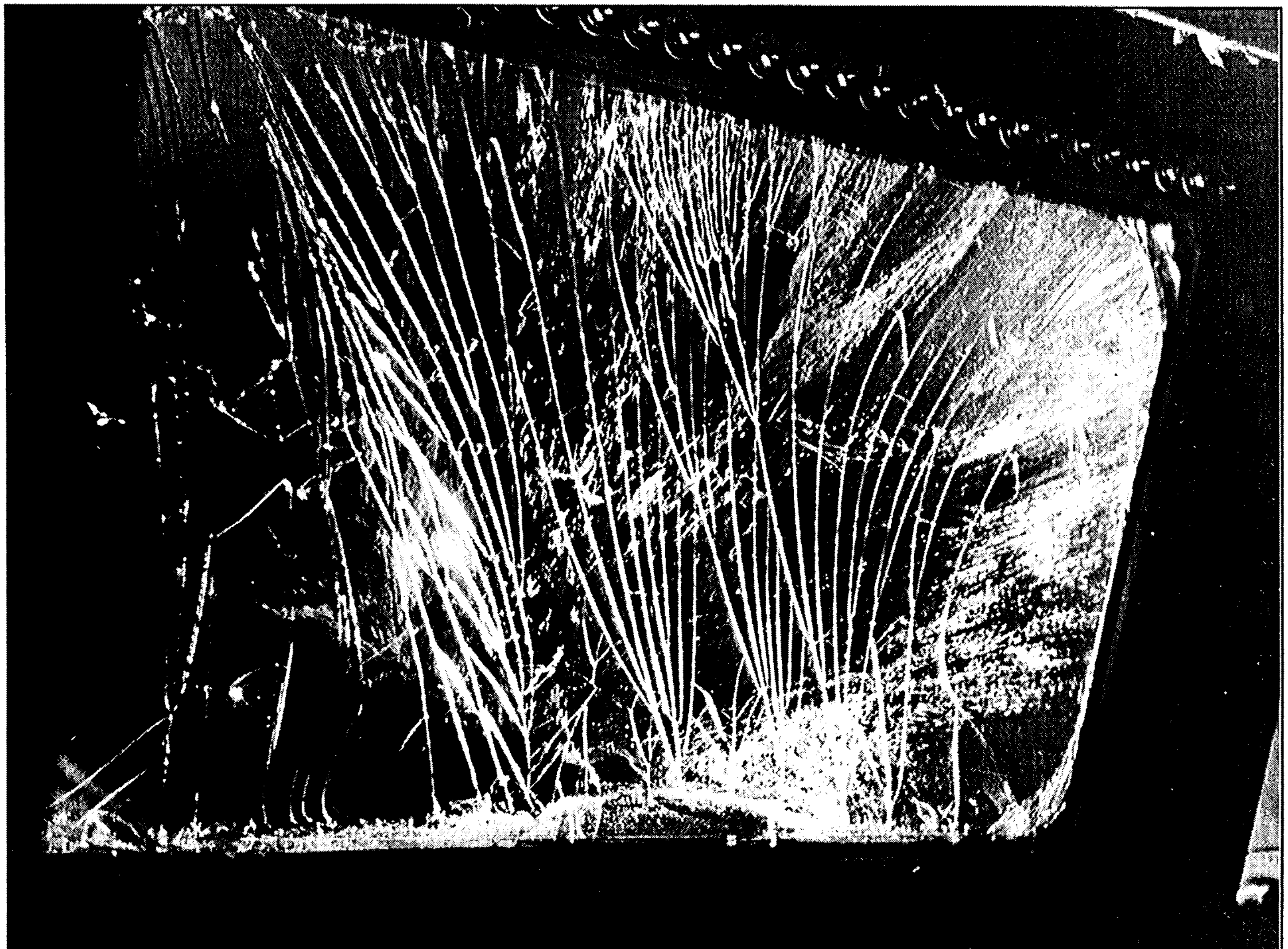


Figure 4.31 C/KC-135 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 251.7 Knots, Rear View (New W/WS, S/N 86-H-10-06-007)

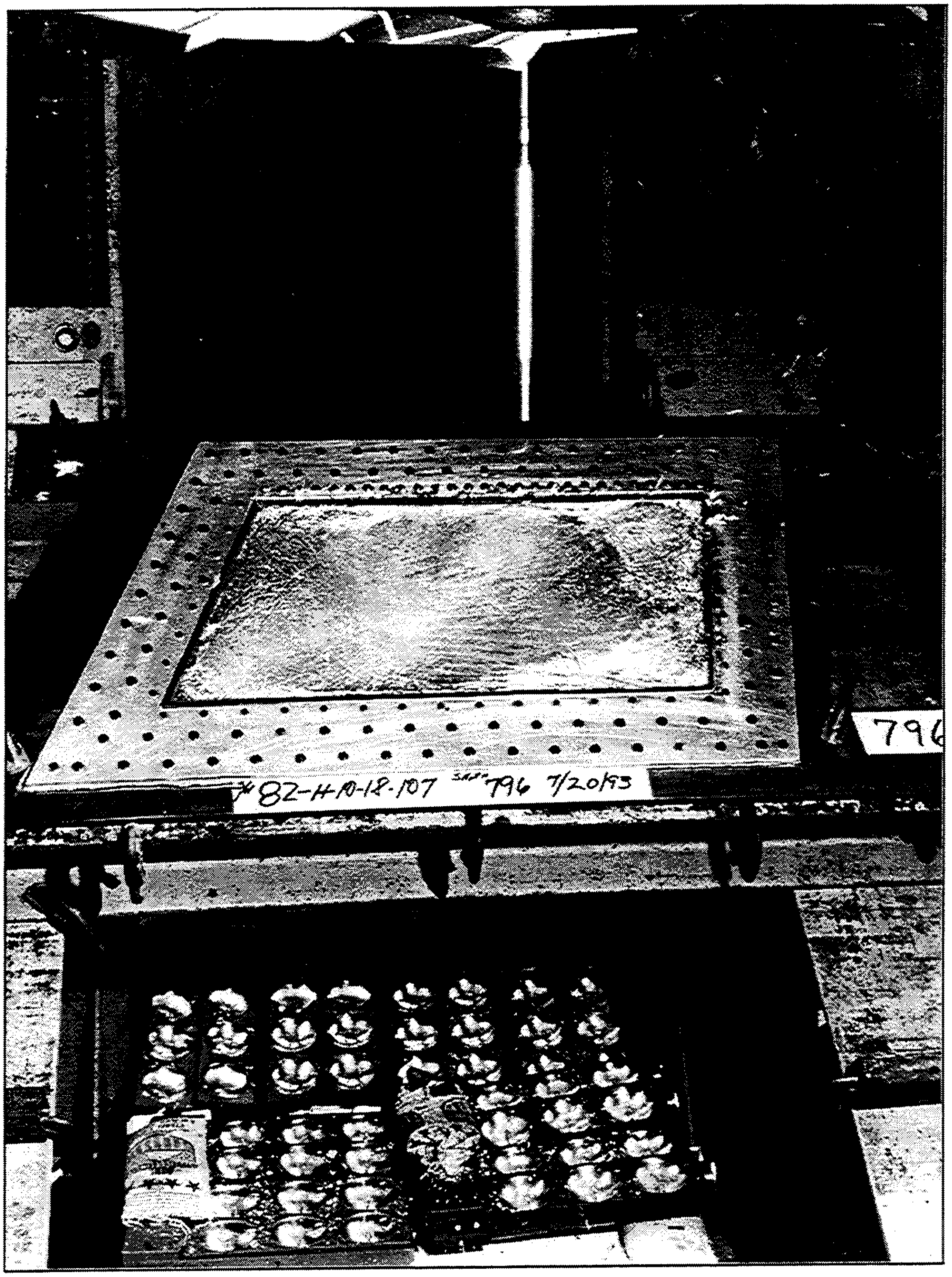


Figure 4.32 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Front View (Repaired W/WS, S/N 82-H-10-18-107)

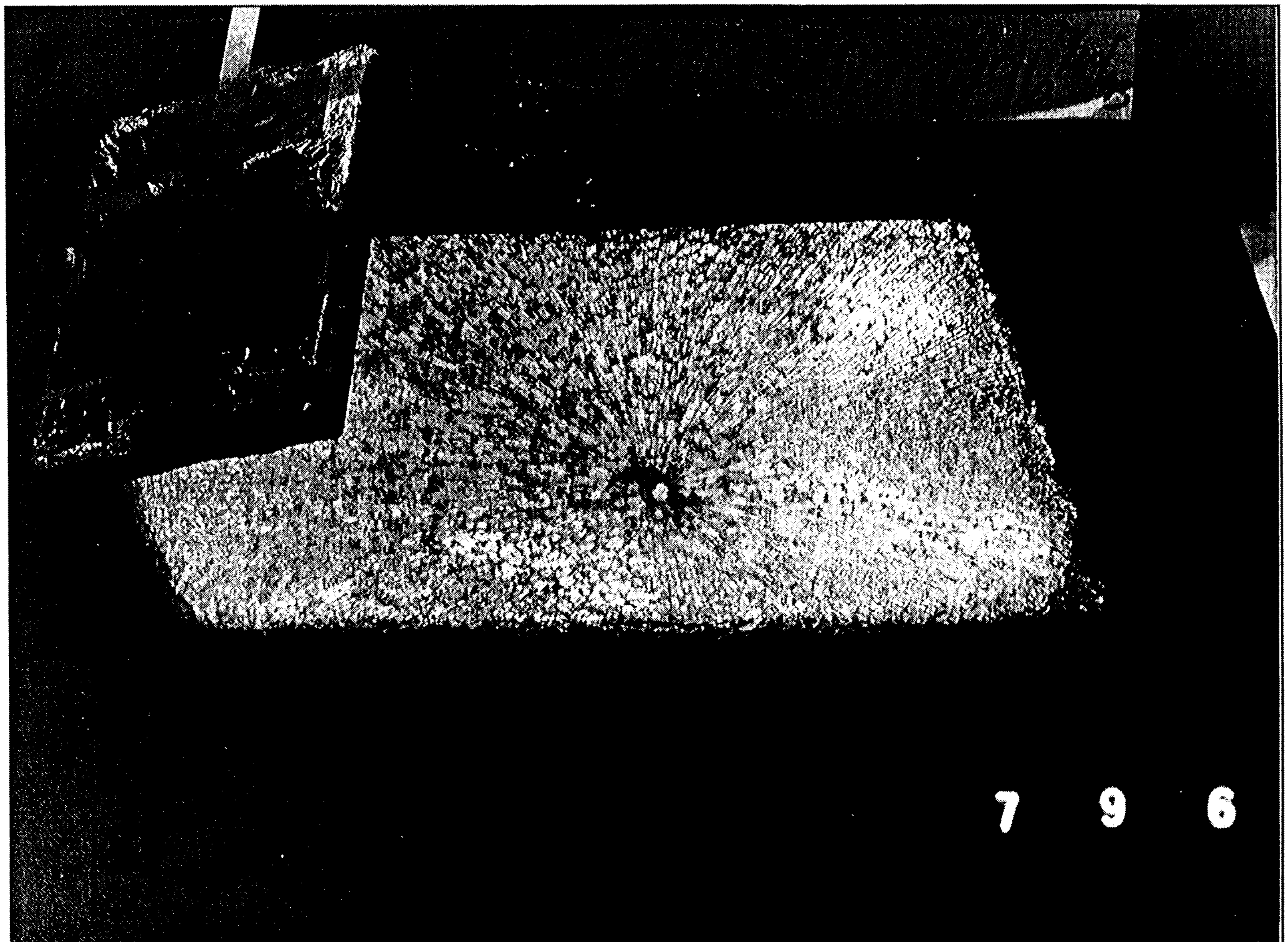


Figure 4.33 C/KC-135 #1 W/WS Showing All Glass Plies Failed From a 4-Pound Bird Impact at 249.4 Knots, Rear View (Repaired W/WS, S/N 82-H-10-18-107)

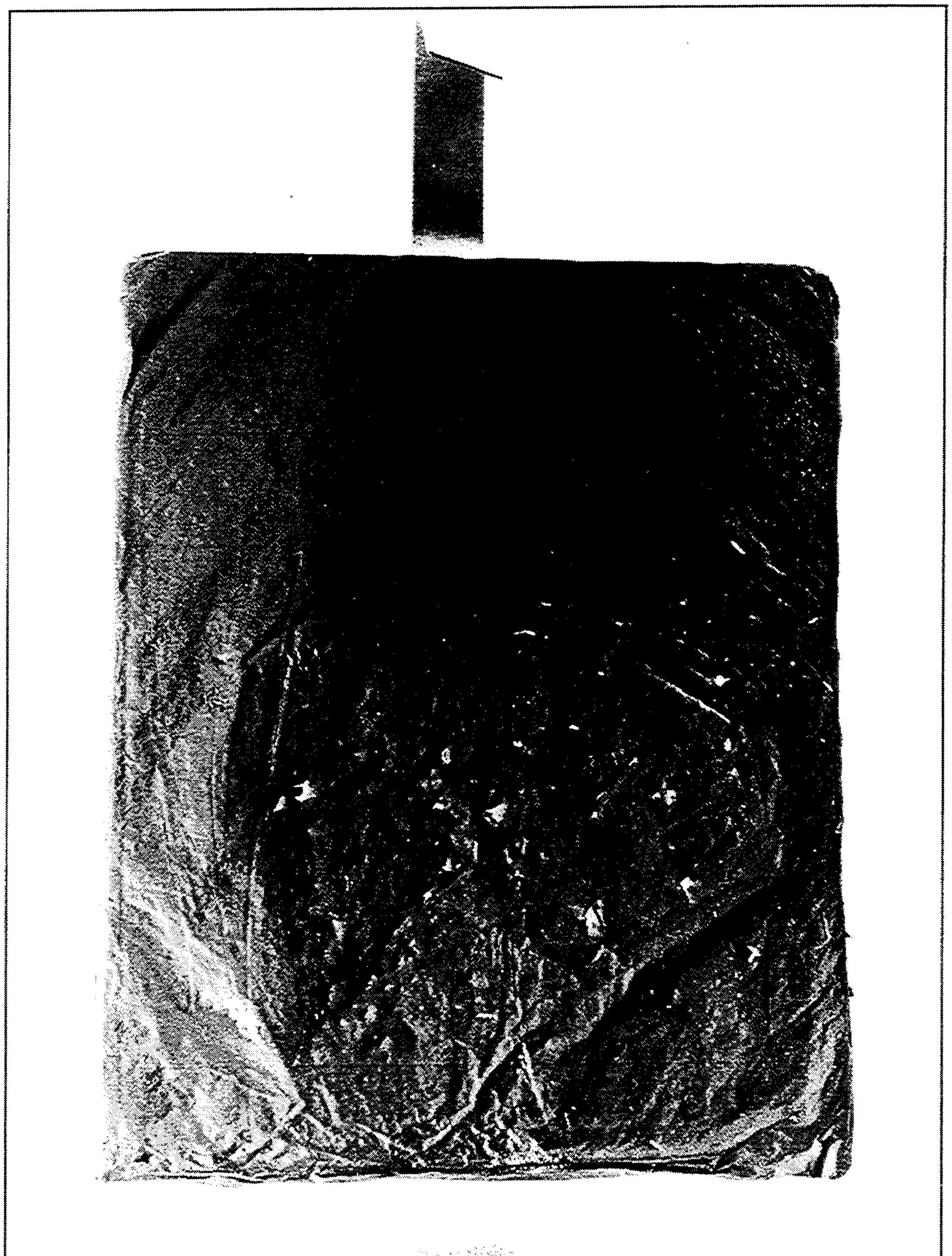


Figure 4.34 Spall Sheet Condition From a 4-Pound Bird Impact at 249.4 Knots on a C/KC-135 #1 W/WS With All Glass Plies Failed (Repaired W/WS, S/N 82-H-10-18-107)

Figure 4.35 C/KC-135 #4 W/WS Showing No Damage From a 4-Pound Bird Impact at 248.7 Knots (Not Repaired W/WS, S/N 4-H-10-9-69)

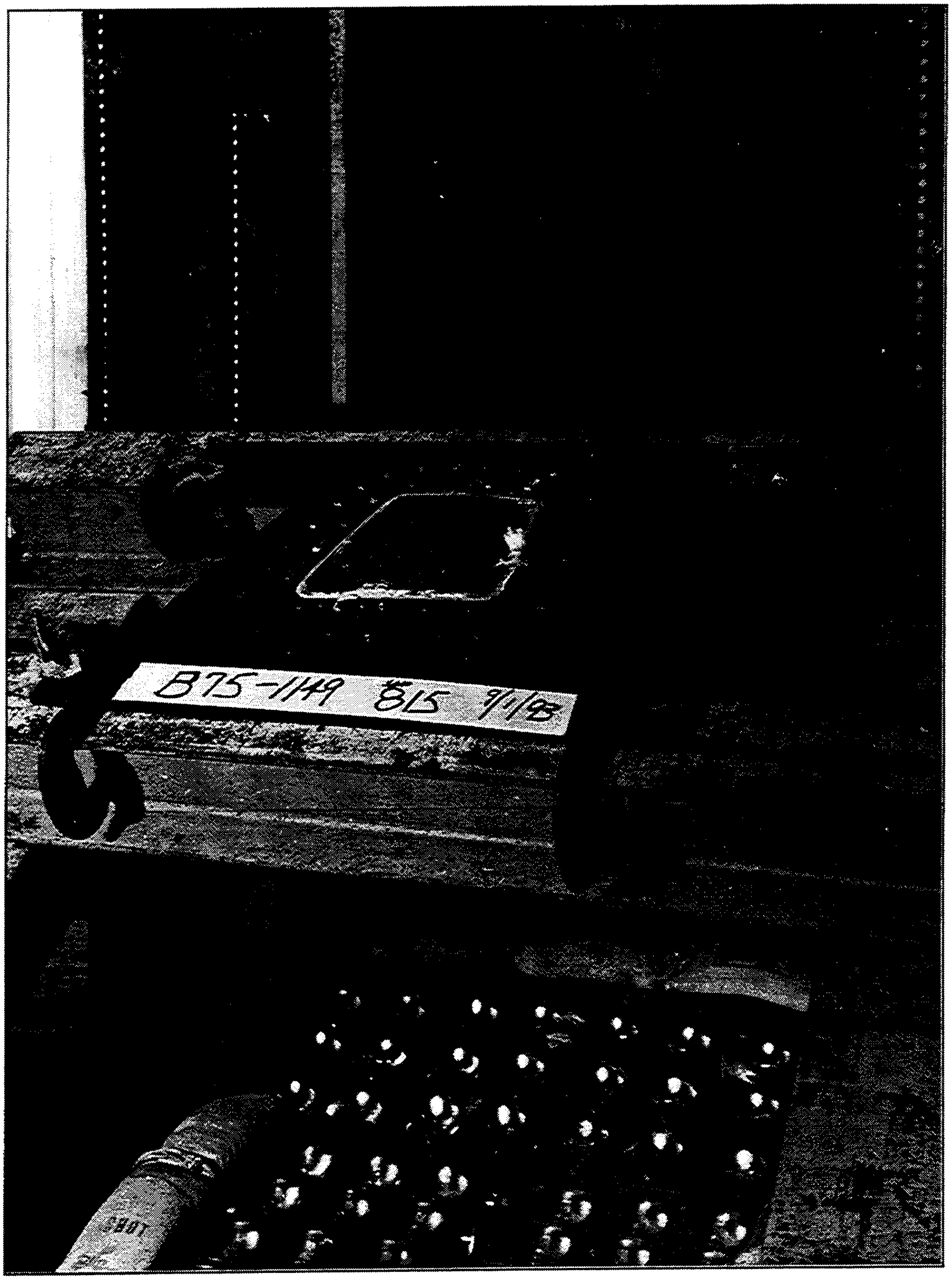


Figure 4.36 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Front View (Repaired W/WS, S/N B75-1149)

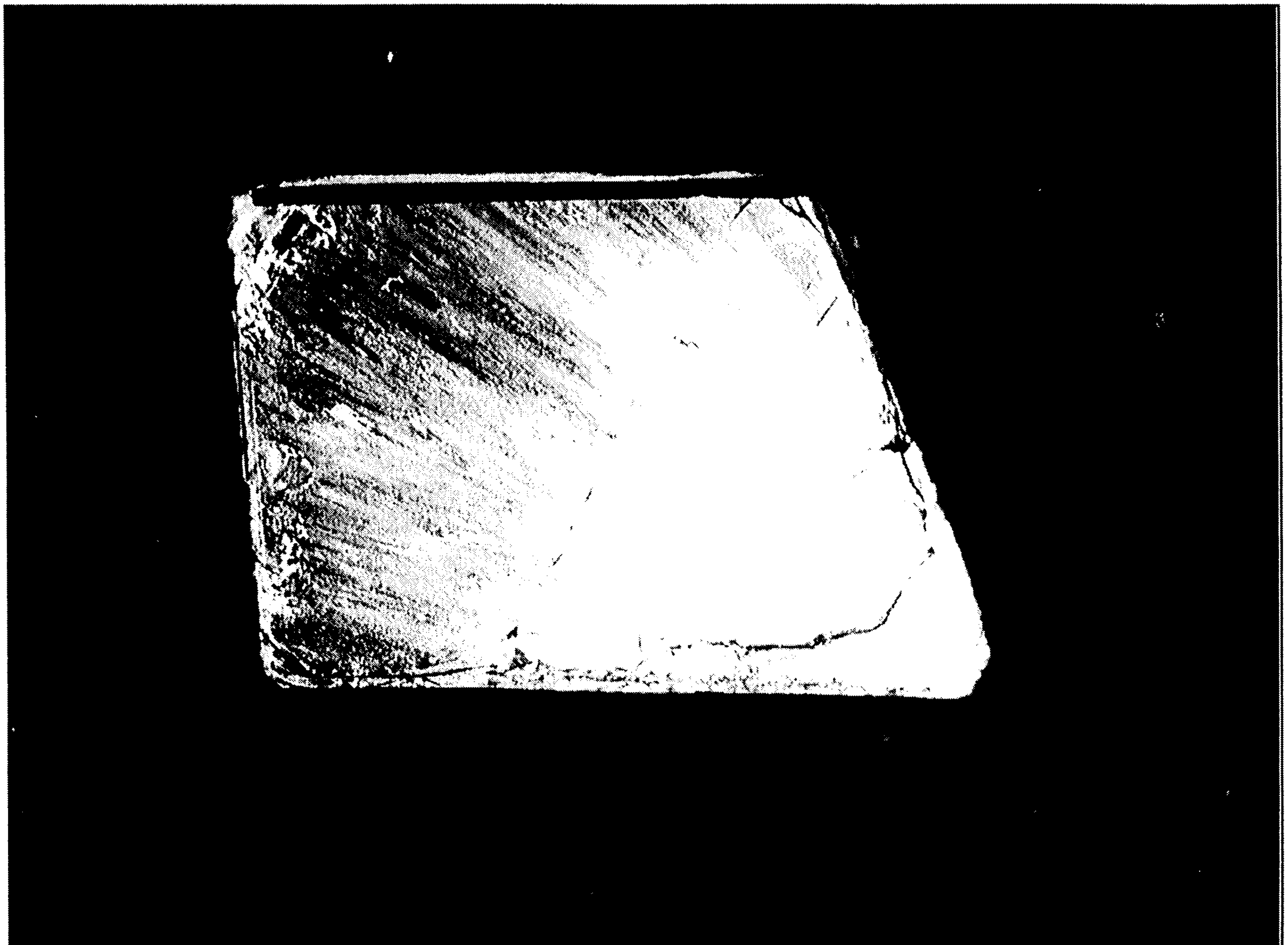


Figure 4.37 C/KC-135 #4 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 247.5 Knots, Rear View (Repaired W/WS, S/N B75-1149)

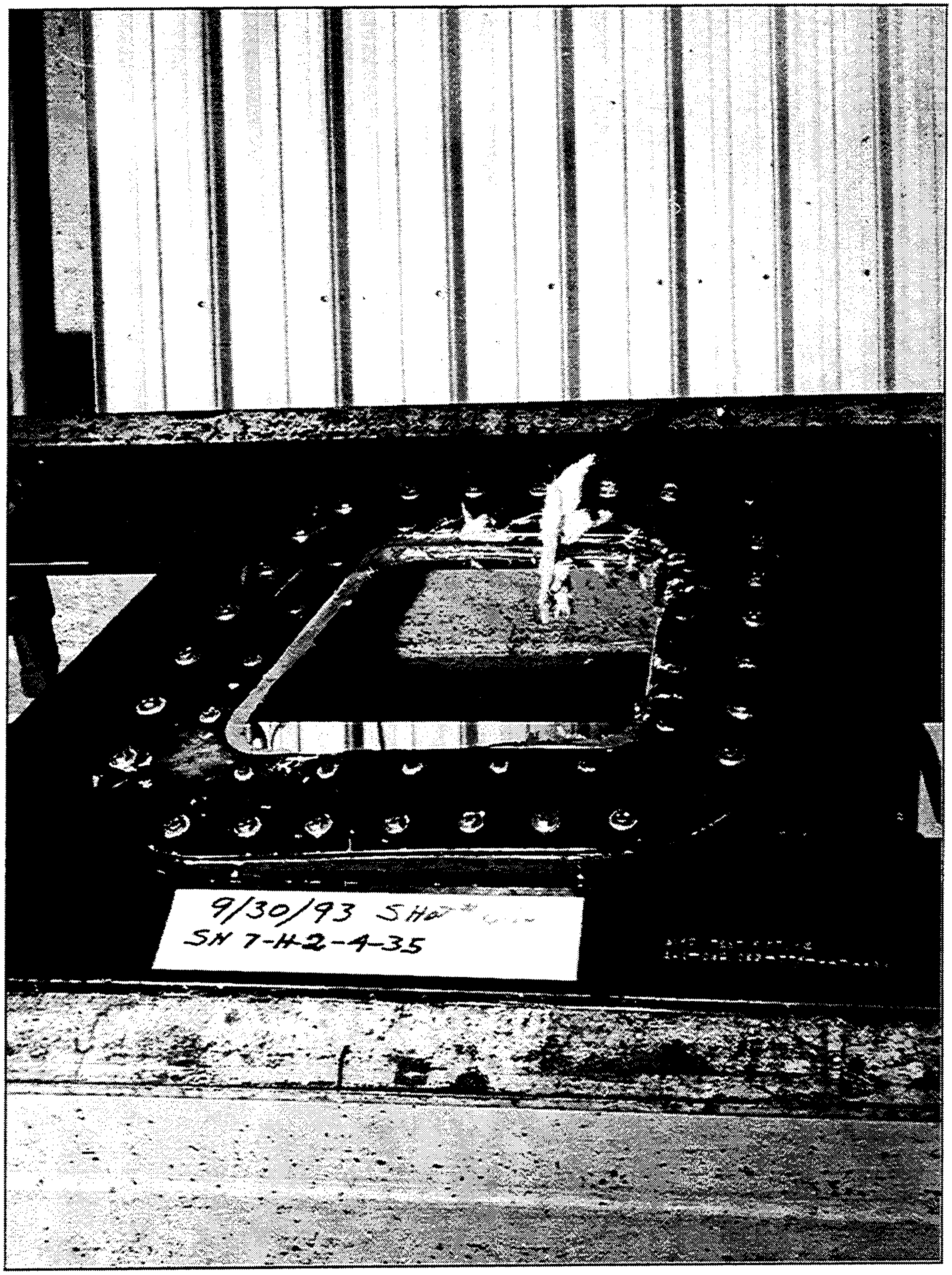


Figure 4.38 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Front View (Not Repaired W/WS, S/N 7-H-2-4-35)

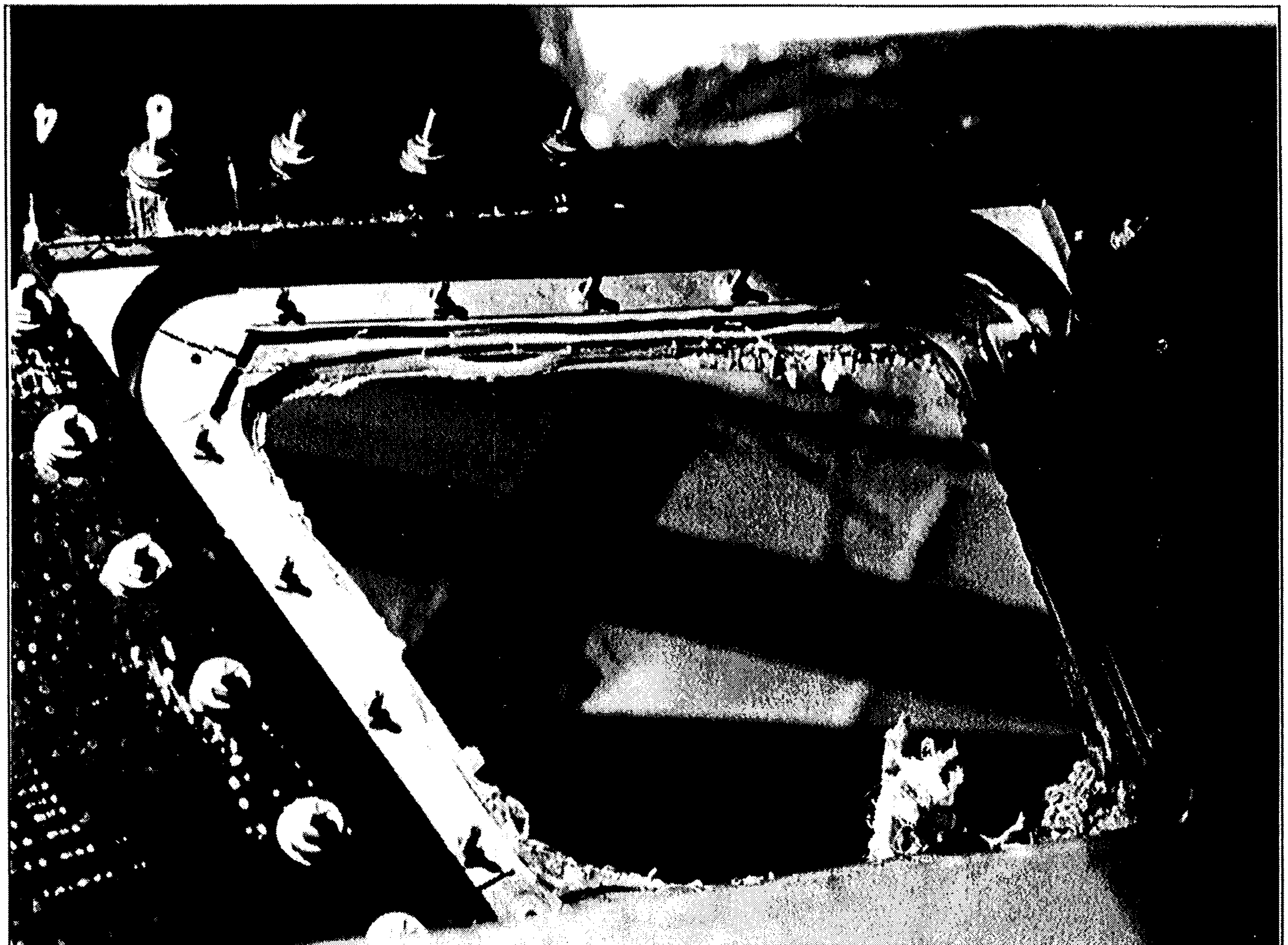


Figure 4.39 C/KC-135 #4 W/WS Showing a Catastrophic All Glass Plies Failure From a 4-Pound Bird Impact at 250.8 Knots, Rear View (Not Repaired W/WS, S/N 7-H-2-4-35)

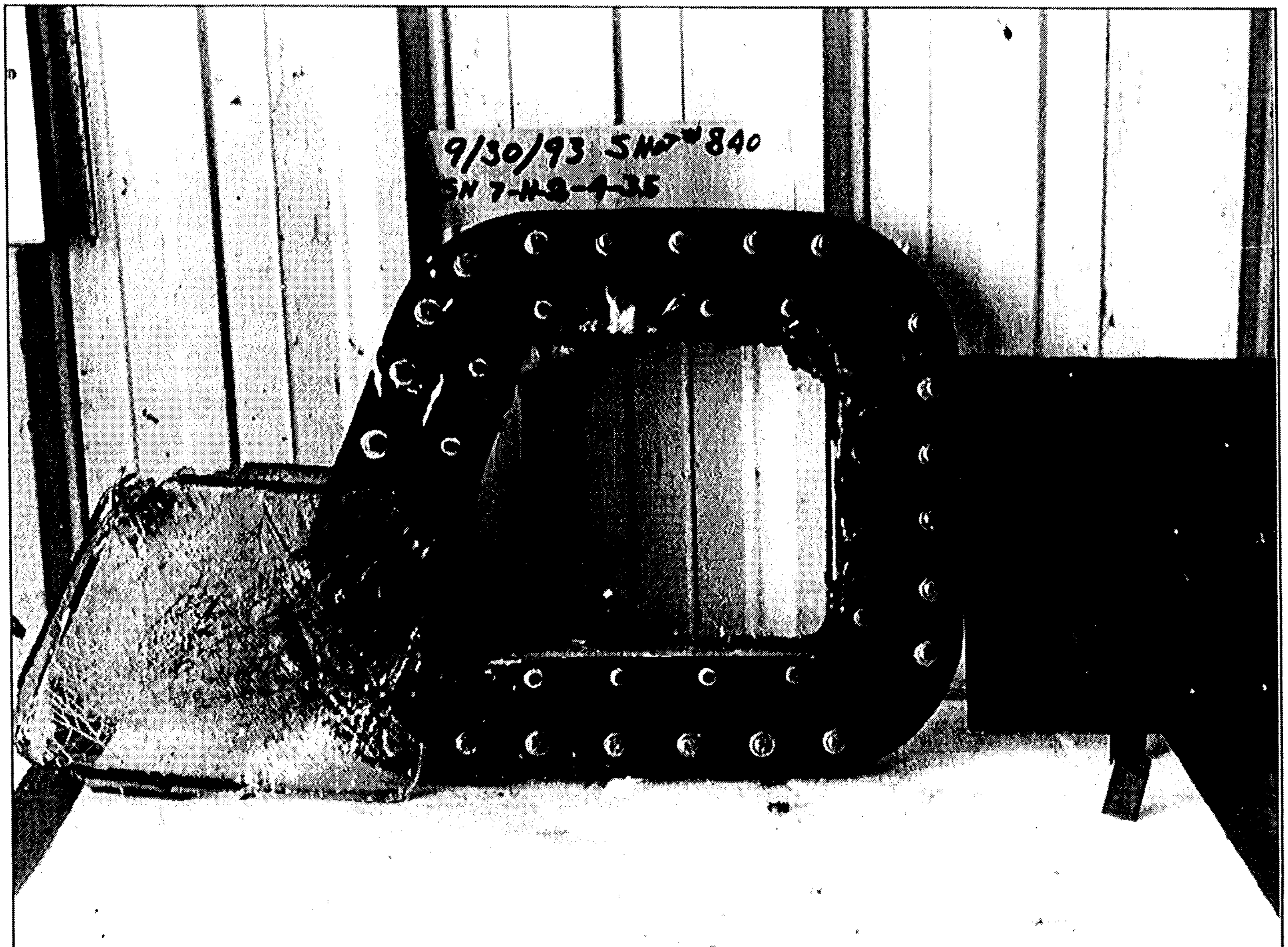


Figure 4.40 Spall Sheet and W/WS Condition From a Catastrophic 4-Pound Bird Impact at 250.8 Knots on a C/KC-135 #4 W/WS (Not Repaired W/WS, S/N 7-H-2-4-35)

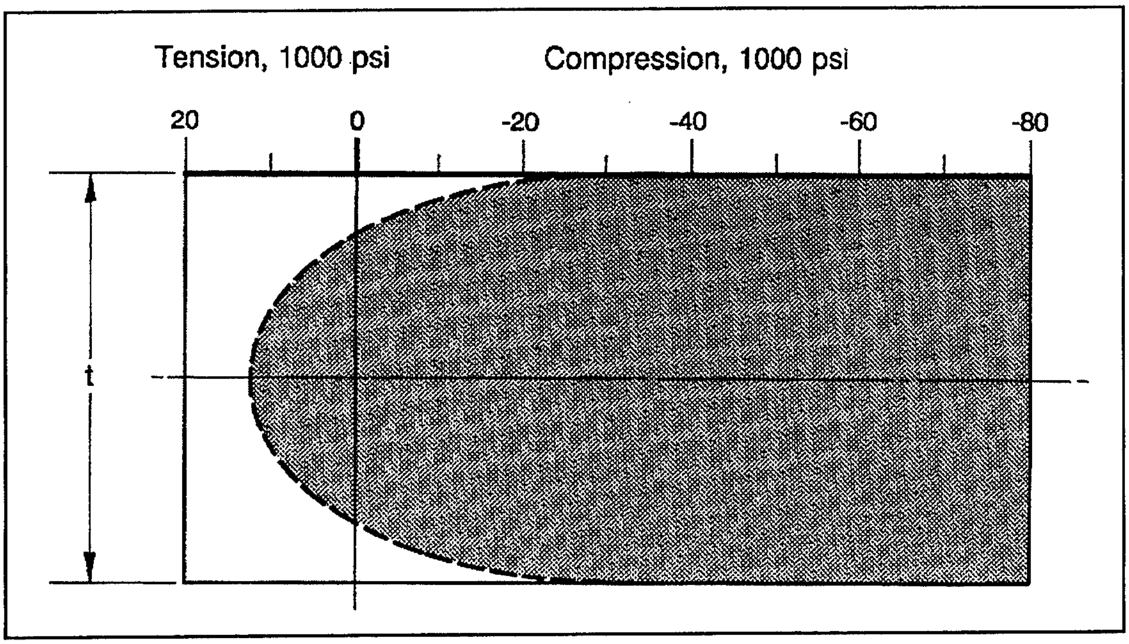


Figure 6.1 Heat Strengthened Glass Residual Stresses

APPENDIX A
REPAIR VENDOR AIR AGENCY CERTIFICATES

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number EZ22812K

This certificate is issued to
NORDAM TRANSPARANCIES DIVISION
whose business address is
510 S. LANSING
TULSA, OKLAHOMA 74120

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved REPAIR STATION

with the following ratings:
LIMITED - SPECIALIZED SERVICE

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY

By direction of the Administrator

Date issued: February 21, 1990

Harold D. Wright
HAROLD D. WRIGHT
ACTING MANAGER, SW-FSDO-15

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number EZ2Z612K is / are limited to the following:

LIMITED RATING:

Specialized Service — Transparency inspection and repair in accordance with Aircarrier Engineering Orders, O.E.M Manuals, and NR 0101-301.

Delegated authorities: None

Date issued or revised: July 3, 1990

For the Administrator:

ROY G. WIEDEN
PRINCIPAL MAINTENANCE INSPECTOR
ASW-FSDO-15

FAA Form 8000-4-1 (1-73) FORMERLY FAA FORM 390.1 PAGE 2

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number JKQR257L

This certificate is issued to
PERKINS AIRCRAFT SERVICES, INC.

whose business address is
5001 NORTH FREEWAY, SUITE B
FORT WORTH, TEXAS 76106

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved Repair Station;

with the following ratings:
LIMITED SPECIALIZED SERVICE (10-08-93)

This certificate, unless canceled, suspended, or revoked, shall continue in effect indefinitely.

By direction of the Administrator

Date issued:
May 2, 1991

Kenneth D. Robinson
Acting Manager, FTW FSDO

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number JKQR257L *is/are limited to the following:*

LIMITED RATINGS:

SPECIALIZED SERVICE	Repair of aircraft windows, transparent enclosures, structural and non-structural composite panels, cores, flaps, ailerons and radomes. Above repairs will be performed in accordance with aircraft manufacturer's repair procedures, air carrier approved instructions and Perkins Aircraft Services, Inc., Process Specification PPS0001, Revision A, dated 09-15-93, as revised.

Delegated authorities: NONE

Date issued or revised:

October 8, 1993

For the Administrator Standley H. Cobb

Standley H. Cobb

PMI, FTW FSDO

FAA Form 8000-4-1 (11-75) FORMERLY FAA FORM 390.1 PAGE 2

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number OX4R430M

This certificate is issued to
THE GLASS DOCTOR

whose business address is
2390 26th AVENUE NORTH
St. Petersburg, Florida 33713

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved REPAIR STATION

with the following ratings:
LIMITED - SPECIALIZED SERVICE

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY

By direction of the Administrator

Date issued:

September 27, 1979
Replacement May 1, 1990

William J. Truebe, Manager
North Florida FSDO-15

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number OX4R430M *is / are limited to the following:*

LIMITED RATINGS:

SPECIALIZED SERVICE - Refurbish and repair aircraft plastic and glass windows, windshields, canopies, navigation light lenses, and other miscellaneous small transparencies, including nicks, chips, delamination, electrical busses and temperature sensor installation.

All inspections and rework will be accomplished in accordance with the following data as applicable to the unit being worked.

Aircraft Manufacturer's Maintenance Manuals/ Instruction.

FAA Approved process Specification, #1979 Cabin and Cockpit Windows dated 12-31-84 (as amended).

Air Carrier's Approved Specifications.

FAA Advisory Circular 43.13-1A, Acceptable Methods, Techniques, and Practices, Chapter 9. Windshields, Enclosures and Exits.

Delegated authorities: NONE

Date issued or revised:

May 1, 1990

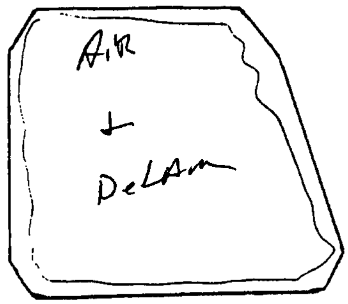
For the Administrator:

Kenneth S. Crockett
Principal Maintenance Inspector

FAA Form 8000-4-1 (1-75) FORMERLY FAA FORM 390.1 PAGE 2

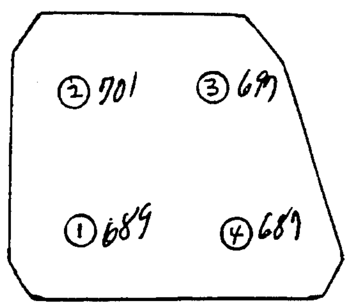
Page 1 of 1

Visual Inspection Map & Comments

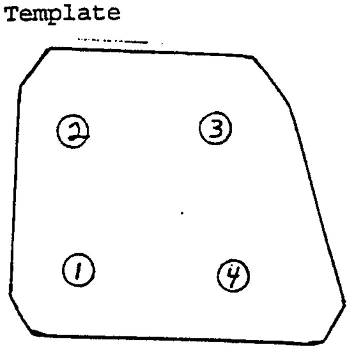


AiR And DeLAm is Located ALL ARound unit.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

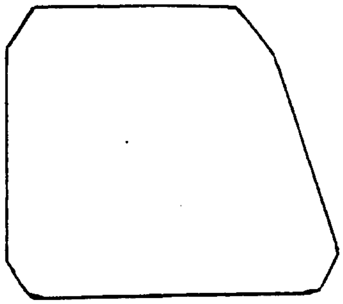
Unit Serial Number: 92 064 H0 470

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 74.4 Ohms	Acc.	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	78.6	MAY 26 1993	22 PPG 77
Haze:	1.3	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 3	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .683 2: .687 3: .686 4: .685	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

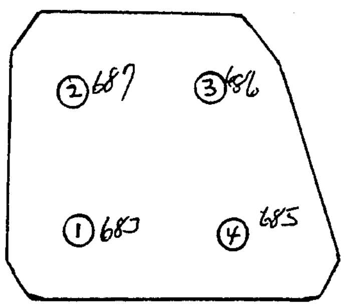
(Comments) ________________

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

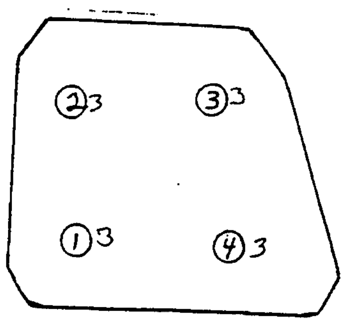
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

Unit Serial Number: 92-098 H0 591

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 67.0 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	78.9	MAY 26 1993	22 PPG 77
Haze:	1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template)	Acc	MAY 26, 1993	22 PPG 77

1: 5 2: 5 3: 3 4: 5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-25-93	22 PPG 28

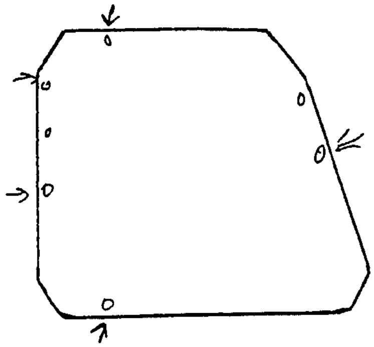
1: .692 2: .683 3: .688 4: .690

	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) Seal Loose But Acceptable

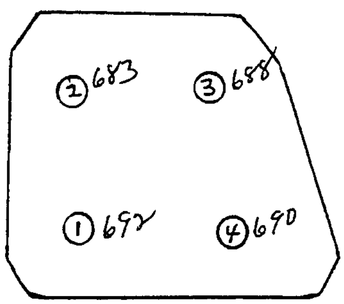
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Visual Inspection Map & Comments

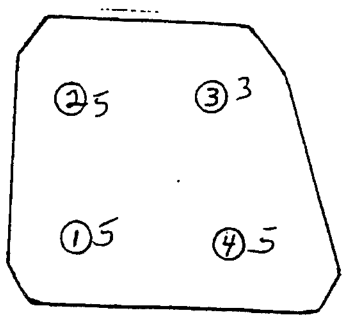


Seal Loose As Marked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

Unit Serial Number: 92-093 H0 392

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 68.0 Ohms	Acc.	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	79.8	MAY 26 1993	22 PPG 77
Haze:	1.0	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template)	Acc	MAY 26 1993	22 PPG 77

1: 5 2: 5 3: 3 4: 5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	7-25-93	22 PPG 28

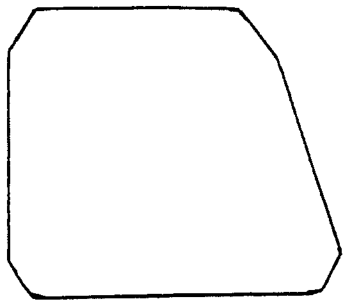
1: .686 2: .686 3: .688 4: .688

	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

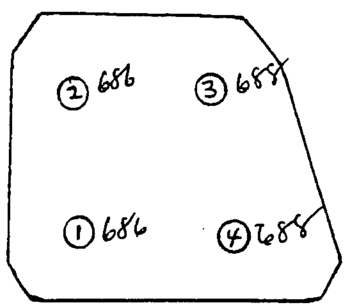
(Comments) ______________________

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

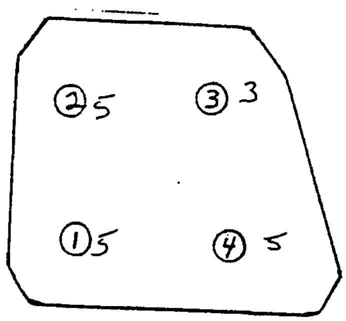
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

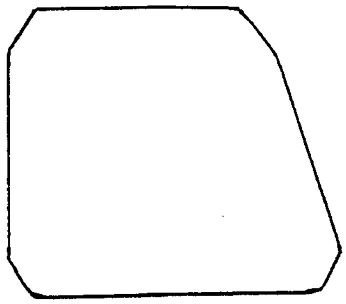
Unit Serial Number: 92-093-HO-388

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 73.7 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.6	MAY 26 1993	22 PPG 77
Haze:	1.5	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 5 2: 5 3: 5 4: 7	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .688 2: .685 3: .691 4: .691	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	PPG 77

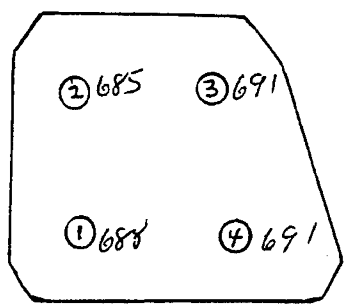
(Comments) ____________________

Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

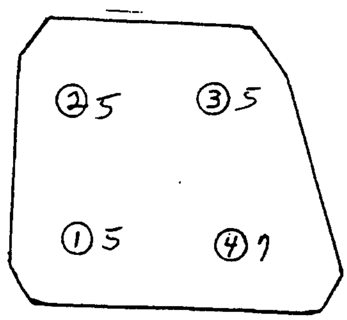
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501 Chg. H

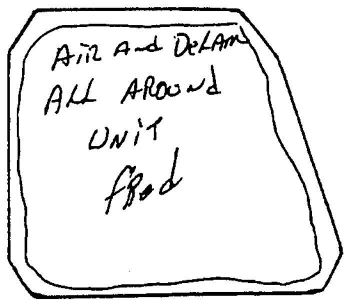
Unit Serial Number: 5-H-12-16-47

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 131.0 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	91.2	MAY 2 6 1993	22PPG43
Haze:	1.5	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: ~~.684~~ <3 2: <3 3: <3 4: <3	A	JUN 0 9 1993	22 PPG 39
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .684 2: .679 3: .685 4: .679	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) WRONG SEAL ON OUTBD SIDE

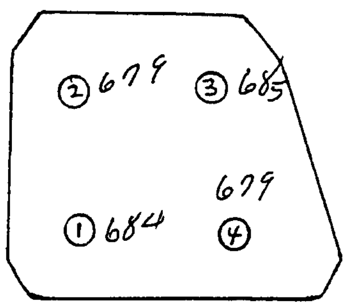
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

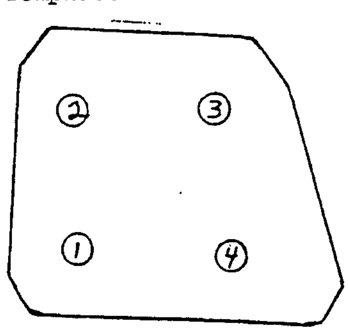


AiR And Delam ALL AROUNd Edge of Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

Unit Serial Number: 84-H-10-15-1225

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 79.3 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.8	MAY 26 1993	22 PPG 77
Haze:	1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template)	Acc	MAY 26 1993	22 PPG 77

1: 3   2: 3   3: 3   4: 5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc 5-25-93	5-25-93	22 PPG 28

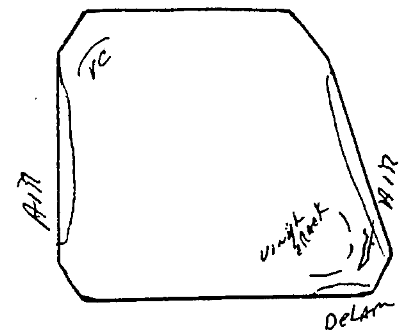
1: .702   2: .704   3: .709   4: .700

	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	ReJ	JUN 02 1993	22 PPG 77
Seal Evaluation:	ReJ	JUN 02 1993	22 PPG 77

(Comments) Wrong seal on outbd side and inside sealant very bad shape

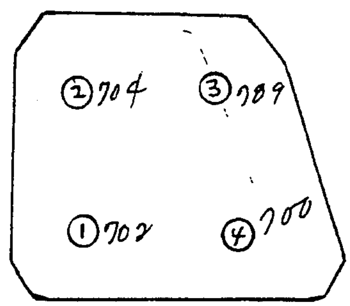
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	ReJ	JUN 02 1993	22 PPG 77

Visual Inspection Map & Comments

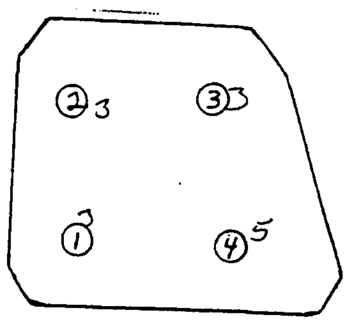


AIR Located ALL Round unit. plus A Large
Amount Located Lower/Fwd. Along with delam
Also Vinly cRacks believe To Be STARTing

Thickness Template



Deviation Template



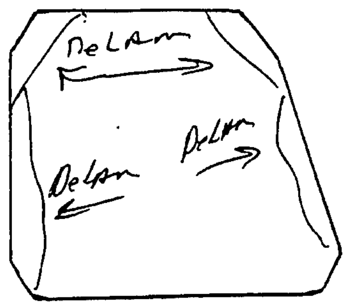
KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-57164-13 Chg-F

Unit Serial Number: 4-H-9-28-87

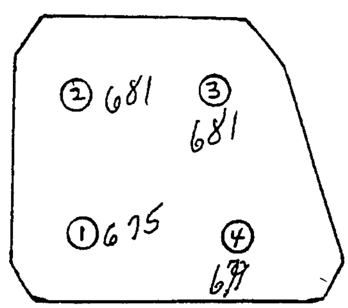
	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 85.6 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	87.1	MAY 2 6 1993	22PPG43
Haze:	1.2	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <3 2: <3 3: <3 4: <3	A	JUN 0 9 1993	22 PPG 39
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .675 2: .681 3: .681 4: .679	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 0 3 1993	22 PPG 77
(Comments)			
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 0 3 1993	[illegible]

Visual Inspection Map & Comments

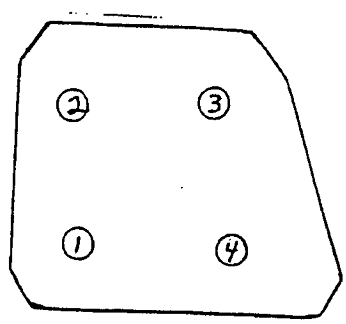


DeLam And Air All Around unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-89357-1

Unit Serial Number: 3-H-4-26-45

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 87.0 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc.	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	81.1	MAY 2 6 1993	22PPG43
Haze:	1.1	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template)	-0-	6-8-93	22 PPG 40

1: <3 2: <3 3: <3 4: <3

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-26-93	22 PPG 28

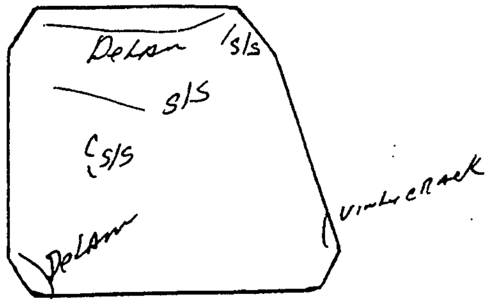
1: .678 2: .679 3: .684 4: .683

	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) NO SEAL AND BAD BUMPER ON OUTBD SIDE

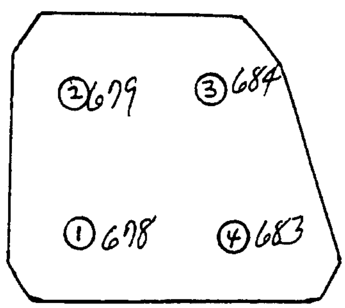
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

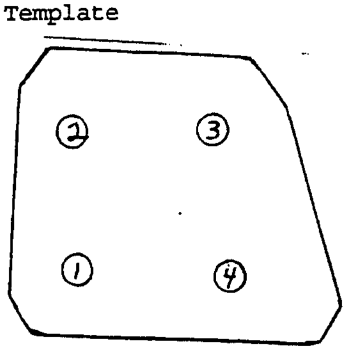


Delam as marked
surface scr, as marked
vinyl crack as marked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-13 Chg. F

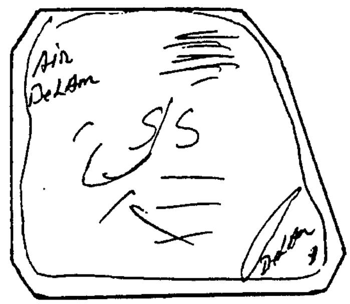
Unit Serial Number: 4-H-10-15-108

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 127.7 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc.	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	81.6	MAY 26 1993	22PPG43
Haze:	1.4	MAY 26 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: < 3 2: < 3 3: < 3 4: < 3	Acc	6-8-93	22 PPG 10
Dimensional Inspection:		JUN 14 1993	
Unit Thickness: (Per Template) 1: .674 2: .681 3: .686 4: .644	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Rej	JUN 03 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 03 1993	22 PPG 77

(Comments) BAD Seal And Bumper

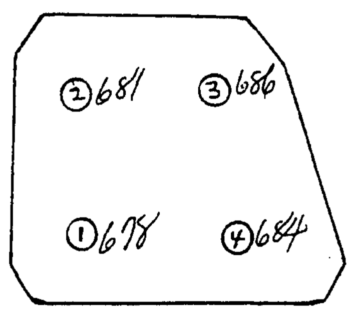
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 03 1993	PPG 77

Visual Inspection Map & Comments

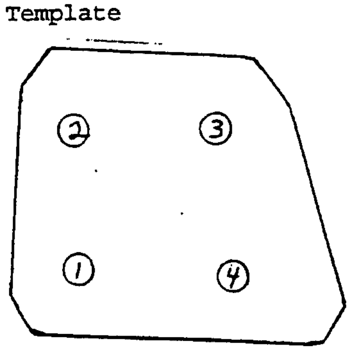


BAd SURfACE SCR LOCATED THROUGHOUT THE UNIT
Both Side
AIR And DeLAm LOCATED ALL AROUND UNIT

Thickness Template



Deviation Template



APPENDIX C
BIRD IMPACT DATA SHEETS

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89364-502 S/N 86-H-10-06-007 Date 6/22/93

Bus to Bus 37.5 OHMS Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.020
Bird Speed (kts)	250.0	251.7

Ambient °F 70°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 783 Test Date: 6/22/93 Tested By: HEG.

Test Results:

OUTBOARD PLY BROKEN. CORE PLY INTACT. SMALL AMOUNT OF BIRD IMPACTED WITNESS PLATE. BIRD ENTERED OVER UPPER EDGE OF WINDOW ON IMPACT. COMPRESSION OF INBOARD MOUNTING O-RINGS PROBABLE CAUSE.

PPG Witness: [signature] Date: 6/22/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-502 S/N 86-H-10-06-30 Date 6/22/93

Bus to Bus 34.8 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250.0	251.1

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 784 Test Date: 6/22/93 Tested By: HEG

Test Results:

NO DAMAGE. SMALL AMOUNT OF BIRD ENTERED OVER TOP EDGE. SAME REASONS AS SHOT # 783.

PPG Witness: H Goodwell Date: 6/22/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-502 S/N 86-H-10-06-22 Date 6/23/93

Bus to Bus 33.6 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250.0	252.8

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 785 Test Date: 6/23/93 Tested By: HEG

Test Results:

NO DAMAGE. NO BIRD RESIDUE ON WITNESS PLATE.

PPG Witness: [signature] Date: 6/23/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-502 S/N 86-H-10-06-096 Date 6/24/93

Bus to Bus 33.5 Delamination chk. Ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73 °F
Temperature O.B.	R.T.	73 °F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	252.6

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

NEW #1 W/S R.H.

Shot No.: 786 Test Date: 6/24/93 Tested By: HEG

Test Results:

NO DAMAGE. NO BIRD RESIDUE ON WITNESS PLATE.

PPG Witness: H Goodall Date: 6/24/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 83-H-9-19-282 Date 7/19/93

Bus to Bus 41.7 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.001
Bird Speed (kts)	250	249.6

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 w/s L.H.

Shot No.: 792 Test Date: 7/19/93 Tested By: HEG

Test Results:

CORE PLY FAILED. NO SPALL ON WITNESS PLATE.

PPG Witness: H Goodall Date: 7/19/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 83H-8-15-756 Date 7/19/93

Bus to Bus 46.0 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	249.4

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 793 Test Date: 7/19/93 Tested By: HEG

Test Results:

ALL PLIES FAILED. MINOR SPALL ON WITNESS PLATE.
NO PENETRATION.

PPG Witness: [signature] Date: 7/19/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 84-H-3-19-220 Date 7/20/93

Bus to Bus 44.5 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.000
Bird Speed (kts)	250	250.1

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S LH.

Shot No.: 794 Test Date: 7/20/93 Tested By: HEG

Test Results:

OUTBOARD PLY FAILED. CORE PLY INTACT.

PPG Witness: H Goodwill Date: 7/20/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 86-H-12-01-146 Date 7/20/93

Bus to Bus 36.5 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	75°F
Temperature O.B.	R.T.	75°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	252.4

Ambient °F ~~CENTER~~ 75°

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 795 Test Date: 7/20/93 Tested By: HEG

Test Results:

NO GLASS BREAKAGE. ALL PLIES INTACT. BENT Z RETAINER BADLY.

PPG Witness: H Goolman Date: 7/20/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 82-H-10-18-107 Date 7/20/93

Bus to Bus 41.3 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	75°F
Temperature O.B.	R.T.	75°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	249.4

Ambient °F 75°F
Impact Loc. CENTER
Installation Angle 45°
Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 796 Test Date: 7/20/93 Tested By: HEG

Test Results:

ALL PLIES FAILED. MINOR SPALL.

PPG Witness: H Goodne Date: 7/20/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 82-H-9-6-235 Date 7/21/93

Bus to Bus 43.4 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	251.0

Ambient °F 70°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 W/S L.H.

Shot No.: 797 Test Date: 7/21/93 Tested By: HEG

Test Results:

OUTBOARD PLY FAILED. CORE PLY INTACT

PPG Witness: [signature] Date: 7/21/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 83-H-11-21-325 Date 7/21/93

Bus to Bus 45.7 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	247.5

Ambient °F 70°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAIRED #1 WS L.H.

Shot No.: 798 Test Date: 7/21/93 Tested By: HEG

Test Results:

ALL PLIES FAILED. CORE PLY SPALLED BUT NONE ON WITNESS PLATE.

PPG Witness: [signature] Date: 7/21/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89354-501 S/N 89-286-110-697 Date 7/22/93

Bus to Bus 38.0 Delamination chk. ok

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	65°F
Temperature O.B.	R.T.	65°F
Bird Wt. (lbs)	4.0	4.000
Bird Speed (kts)	250	250.8

Ambient °F 65°F

Impact Loc. CENTER

Installation Angle 45°

Sweep Back Angle 30°

REPAILED

Shot No.: 799 Test Date: 7/22/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: H Goodwill Date: 7/22/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-89357-1 S/N B75-1149 Date 9/1/93

Bus to Bus 71.1 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	71°F
Temperature O.B.	R.T.	71°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	247.5

Ambient °F 71°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 815 Test Date: 9/1/93 Tested By: HEG

Test Results:

OUTBOARD GLASS FAILED. BIRD PENETRATION BETWEEN O.B. RETAINER & GASKET ALONG AFT EDGE & AT TOP AFT CORNER. BENT 14 MOUNTING BOLTS.

PPG Witness: [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-064-140-471 Date 9/1/93

Bus to Bus 69.8 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	71°F
Temperature O.B.	R.T.	71°F
Bird Wt. (lbs)	4.0	4.020
Bird Speed (kts)	250	251.3

Ambient °F 71°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

NEW #4 WINDOW L.H.

Shot No.: 816 Test Date: 9/1/93 Tested By: HEG

Test Results:

NO DAMAGE. SMALL AMOUNT OF BIRD PENETRATION BETWEEN O.B. RETAINER & WINDOW GASKET. NO BENT BOLTS.

PPG Witness: H. [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-064-H0-473 Date 9/1/93

Bus to Bus 69.4 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	248.9

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

NEW #4 WINDOW L.H.

Shot No.: 817 Test Date: 9/1/93 Tested By: HEG

Test Results:

NO DAMAGE. NO BENT BOLTS. MINOR BIRD PENETRATION AFT EDGE & BOTTOM EDGE.

PPG Witness: [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-059-H0-350 Date 9/1/93

Bus to Bus 70.1 Delamination chk. OK

Requirements:

High Speed Film (3 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.020
Bird Speed (kts)	250	225.1

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

Shot No.: 818 Test Date: 9/1/93 Tested By: HEG

Test Results:

NO TEST. MISFIRE. CAMERA FILM BROKE. LARGE GLASS CHIP BLOWN OFF LOWER AFT CORNER OPPOSITE TERMINAL BLOCK. UNIT WILL BE REPLACED BY PPG & DATA REISSUED.

PPG Witness: [signature] Date: 9/1/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. S-71764-501 S/N 92-025-HO-006 Date 9/29/93

Bus to Bus 69.3 Delamination chk. OK

Requirements:

High Speed Film (2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	248.4

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

NEW #4 WINDOW L.H.

Shot No.: 835 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE.

PPG Witness: [signature] Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 92-119-140-186 Date 9/29/93

Bus to Bus 64.8 Delamination chk. OK

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	247.8

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

NEW #4 WINDOW L.H. - REPLACEMENT FOR SHOT #818

Shot No.: 836 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: [signature] Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 85-11-07-01-276 Date 9/29/93

Bus to Bus OPEN Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	73°F
Temperature O.B.	R.T.	73°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	248.7

Ambient °F 73°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 837 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: [signature] Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 90-173-HO-721 Date 9/29/93

Bus to Bus OPEN Delamination chk. OK

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	74°F
Temperature O.B.	R.T.	74°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	247.1

Ambient °F 74°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 838 Test Date: 9/29/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: [signature] Date: 9/29/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-13 CWG F S/N 5-H-5-23-84 Date 9/30/93

Bus to Bus 118.0 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (~~2~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	70°F
Temperature O.B.	R.T.	70°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	251.2

Ambient °F 70°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 839 Test Date: 9/30/93 Tested By: HEG

Test Results:

OUTBOARD PLY BROKEN. NO BIRD PENETRATION.
INTERLAYER TORN IN LOWER FORWARD CORNER.

PPG Witness: [signature] Date: 9/30/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 CHG. H. S/N 7-H-2-4-35 Date 9/30/93

Bus to Bus 119.8 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	71°F
Temperature O.B.	R.T.	71°F
Bird Wt. (lbs)	4.0	4.005
Bird Speed (kts)	250	250.8

Ambient °F 71°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REMAINED #4 WINDOW · L.H.

Shot No.: 840 Test Date: 9/30/93 Tested By: HEG

Test Results:

ENTIRE GLASS SECTION TORN OUT AT INSERT.
PICTURE FRAME REMAINING IN FIXTURE.

PPG Witness: [signature] Date: 9/30/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764 S/N 4-H-10-9-69 Date 9/30/93

Bus to Bus 85.0 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	251.0

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 841 Test Date: 9/30/93 Tested By: HEG

Test Results:

NO DAMAGE

PPG Witness: H. Goodman Date: 9/30/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 82-H-12-6-392 Date 9/30/93

Bus to Bus 79.7 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (~~3~~ 2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.010
Bird Speed (kts)	250	250.8

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REPAIRED #4 WINDOW L.H.

Shot No.: 842 Test Date: 9/30/93 Tested By: HEG

Test Results:

NO DAMAGE.

PPG Witness: [signature] Date: 9/30/93

PPG Industries-Bird Impact Data Sheet
KC-135 Test Program
for
Battelle

Sample I.D. 5-71764-501 S/N 6-H-12-02-36 Date 10/1/93

Bus to Bus 96.8 Delamination chk. SEE DATA SHEET

Requirements:

High Speed Film (2 cameras) YES Spall Shield Installed YES

Test Conditions	Requested	Actual
Temperature I.B.	R.T.	72°F
Temperature O.B.	R.T.	72°F
Bird Wt. (lbs)	4.0	4.015
Bird Speed (kts)	250	250.3

Ambient °F 72°F

Impact Loc. CENTER

Installation Angle 58.2°

Sweep Back Angle 35°

REMAILED #4 WINDOW L.H.

Shot No.: 843 Test Date: 10/1/93 Tested By: HEC

Test Results:

BOTH GLASS PLIES FAILED. 4" TEAR IN INTERLAYER AROUND LOWER FORWARD CORNER.

PPG Witness: H. Goodrel Date: 10/1/93

APPENDIX B
GENERAL INSPECTION DATA SHEETS

This page intentionally left blank.

KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-062

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 34.3 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:		5-25-93	22 PPG 28
S.E. Resistance: 307	Acc	5-24-93	22 PPG 28
Insulation Test (2500 VAC) Power to S.E.:	ok	MAY 25 1993	22 PPG 77
S.E. to Metal:	ok		
S.E. to S.E.:	ok		
Nesa Scratch Test (350 VAC):	ok	MAY 25 1993	22 PPG 77
Light Transmittance:	77.6	MAY 25 1993	22 PPG 77
Haze:	1.1	MAY 25 1993	22 PPG 77
Photo (Single Exposure):		MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)	Acc	5-25-93	22 PPG 28

1: 3.0 2: 2.0 3: 1.0 4: 3.0
5: 1.0 6: 2.0 7: 2.0 8: 2.0

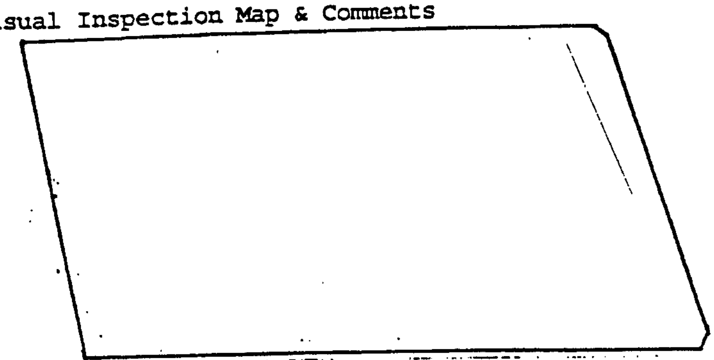
	Acc/Rej	Date	Inspector
Dimensional Inspection:		~~5-25-93~~	~~22 PPG 28~~
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.100 2: 1.102 3: 1.103 4: 1.103
5: 1.105 6: 1.104 7: 1.105 8: 1.103
9: 1.105 10: 1.105 11: 1.103 12: 1.100

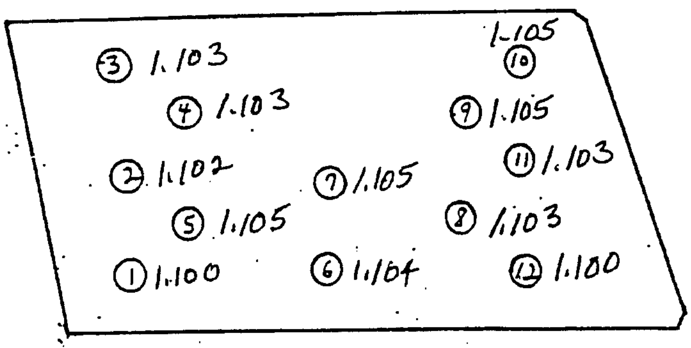
	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Acc	JUN 02 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks / Acp 6-3-93 PPG 77

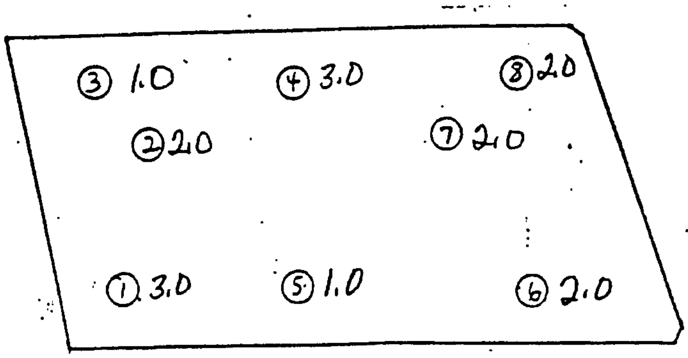
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-092

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	34.9 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.309	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	75.1 31	A	JUN 09 1993	22 PPG 39
Light Transmittance:	73.7	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 1.0 2: 2.0 3: 0.5 4: 1.0
5: 2.0 6: 0.5 7: 1.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-25-93	22 PPG 28

1: 1.100 2: 1.100 3: 1.100 4: 1.100
5: 1.102 6: 1.100 7: 1.105 8: 1.102
9: 1.100 10: 1.098 11: 1.102 12: 1.100

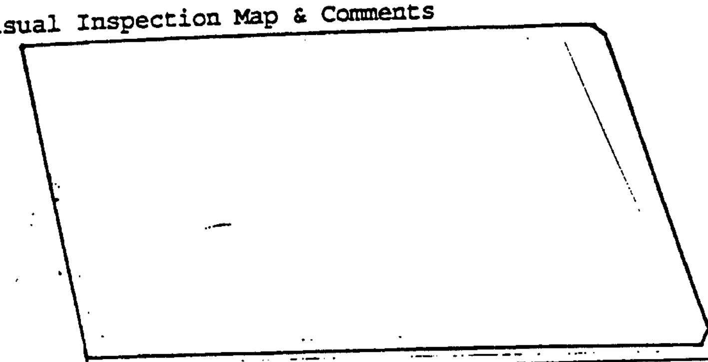
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 04 1993	22 PPG 77

(Comments) ______

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 04 1993	22 PPG 77

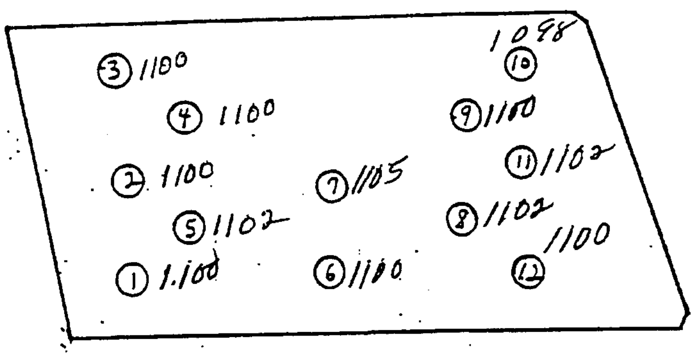
Check for vinyl cracks Aac JUN 04 1993 22 PP8 77

Visual Inspection Map & Comments

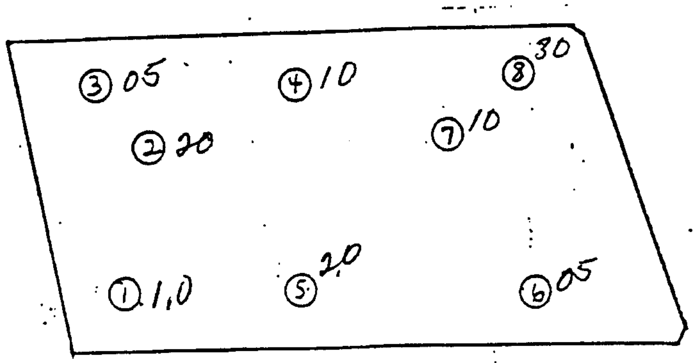


Some Air

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89364-502

Unit Serial Number: 86-4-10-06-013

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	33.8 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	314	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc ok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc ok		
	S.E. to S.E.:	Acc ok		
Nesa Scratch Test (350 VAC):		Acc ok	MAY 25 1993	22 PPG 77
Light Transmittance:		Acc 79.7	MAY 25 1993	22 PPG 77
Haze:		Acc 1.2	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 2 · 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 2.0 3: 0.5 4: 1.0
5: 1.0 6: 1.0 7: 2.0 8: 0.5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

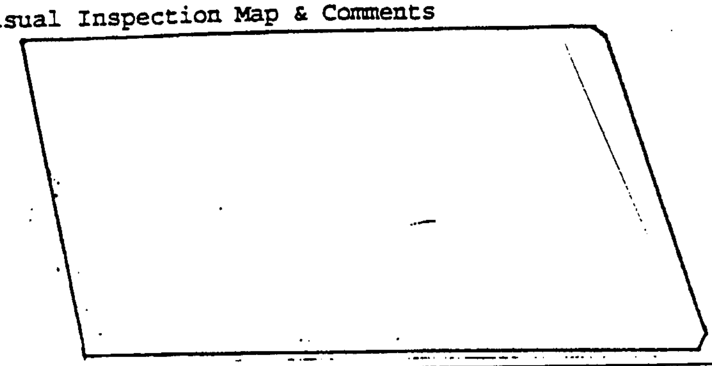
1: 1.110 2: 1.100 3: 1.095 4: 1.098
5: 1.092 6: 1.093 7: 1.094 8: 1.094
9: 1.094 10: 1.093 11: 1.091 12: 1.095

	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Acc	JUN 02 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

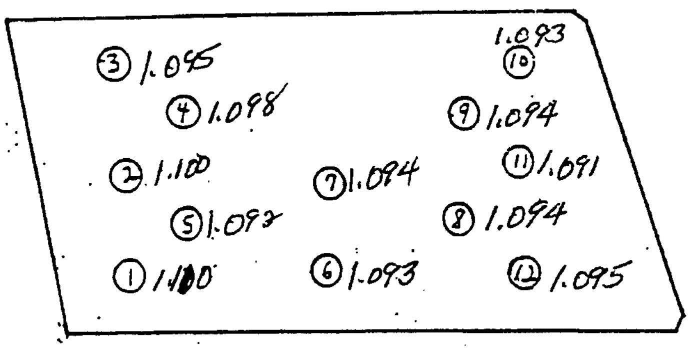
1.103
1.0

Check for vinyl cracks DCR 6-3-93 22.PPr

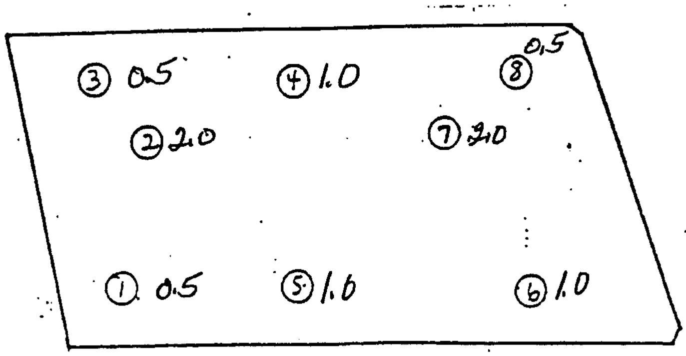
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-048

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	36.6 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	310	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	ok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	ok		
	S.E. to S.E.:	ok		
Nesa Scratch Test (350 VAC):		OK	MAY 25 1993	22 PPG 77
Light Transmittance:		80.9	MAY 25 1993	22 PPG 77
Haze:		1.1	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 77

1: 2.0 2: 2.0 3: 2.0 4: 0.5
5: 1.0 6: 0.5 7: 1.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.095 2: 1.106 3: 1.093 4: 1.095
5: 1.093 6: 1.097 7: 1.102 8: 1.100
9: 1.100 10: 1.105 11: 1.097 12: 1.197

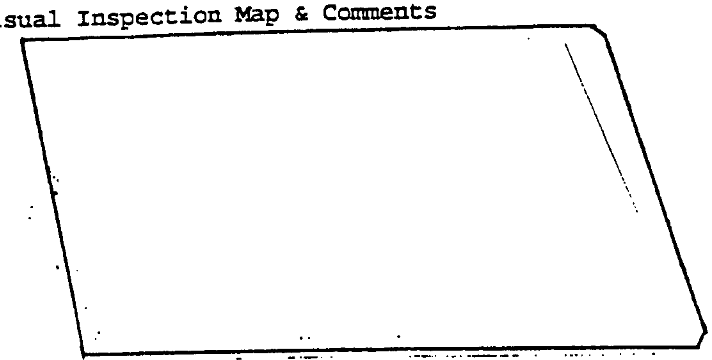
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) ______

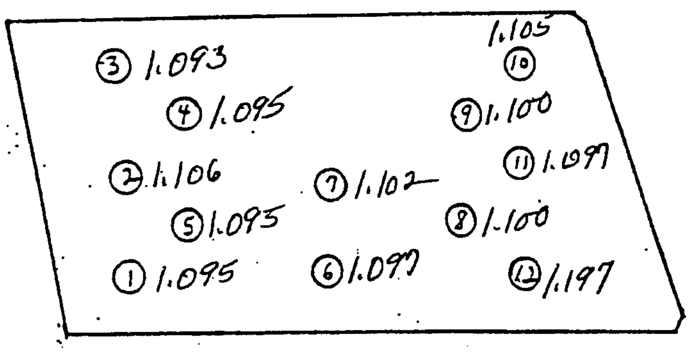
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks AOL 6-3-93 22 SEP 77

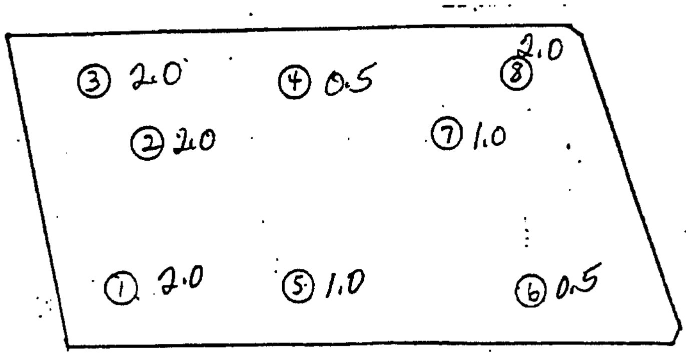
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-3096

Unit Serial Number: 83-H-11-7-432

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.0 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-26-93	22 PPG 28
S.E. Resistance:	315+315	Acc.	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):	413	A	JUN 09 1993	22 PPG 39
Light Transmittance:	76.4	A	JUN 09 1993	22 PPG 39
Haze:	.8	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-26-93	22 PPG 22

1: 3.0 2: 2.0 3: 1.0 4: 3.0
5: 1.0 6: 1.0 7: 2.0 8: 1.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

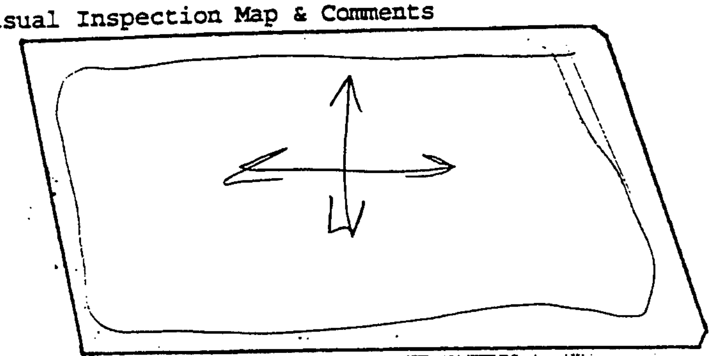
1: 1.102 2: 1.102 3: 1.100 4: 1.101
5: 1.103 6: 1.102 7: 1.102 8: 1.102
9: 1.102 10: 1.099 11: 1.102 12: 1.098

Seal Evaluation: Rej — JUN 04 1993 — 22 PPG 77
(Comments) The Seal itself looks good and Bumper did flow but Air & Dolam. and water enter unit

Visual Inspection: Rej — JUN 04 1993 — 22 PPG 77
(Place comments on attached sheet)

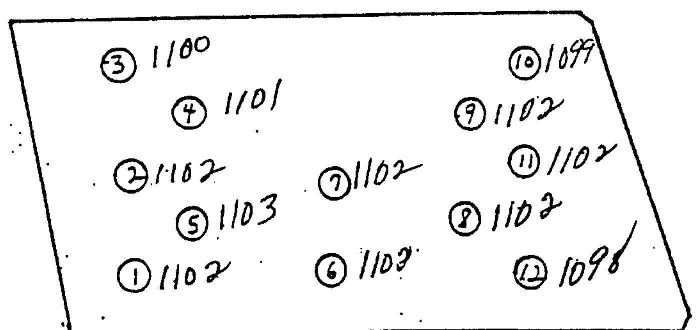
Check for vinyl cracks   Doc   JUN 04 1993   22 PPG 77

Visual Inspection Map & Comments

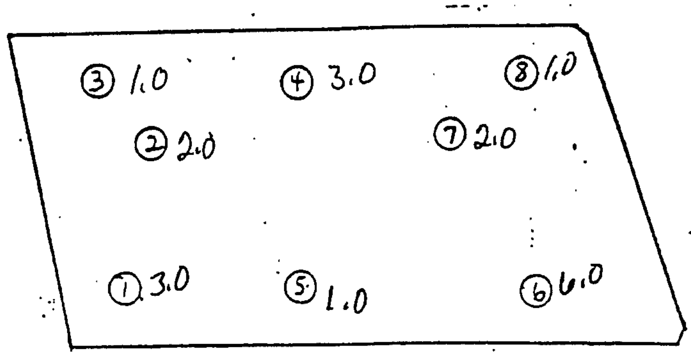


AIR, DelAm And WATER JUST About All the WAY Around UNIT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-10-18-105

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	43.8 Ohms		5-21-93	22 PPG 28
Thermal Image:	3		5-20-93	22 PPG 28
S.E. Resistance:	368	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	44.5 Rei H6#	A	JUN 09 1993	22 PPG 39
Light Transmittance:	75.6	A	JUN 09 1993	22 PPG 39
Haze:	.8	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993 JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-26-93	22 PPG 28

1: 1.0 2: 2.0 3: 1.0 4: 0.5
5: 2.0 6: 1.0 7: 3.0 8: 0.5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

1: 1.099 2: 1.097 3: 1.100 4: 1.100
5: 1.099 6: 1.098 7: 1.099 8: 1.099
9: 1.092 10: 1.096 11: 1.095 12: 1.095

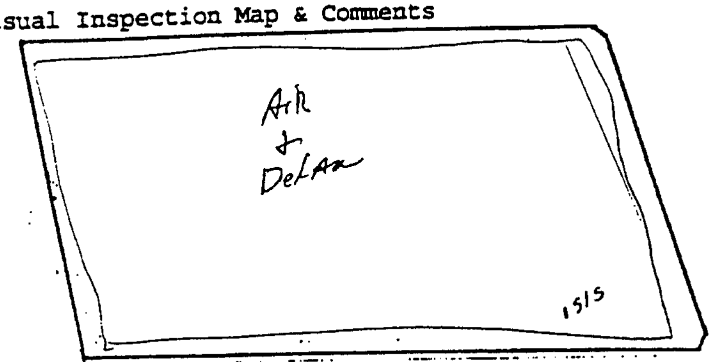
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) Seal needs to be cut too size

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

Check for vinyl cracks ACC JUN 0 4 1993 :2 PP6 77

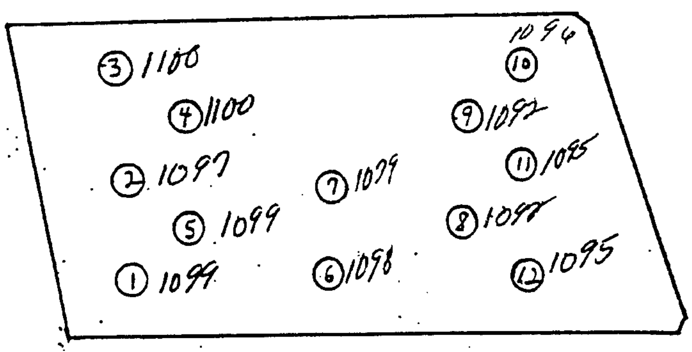
Visual Inspection Map & Comments



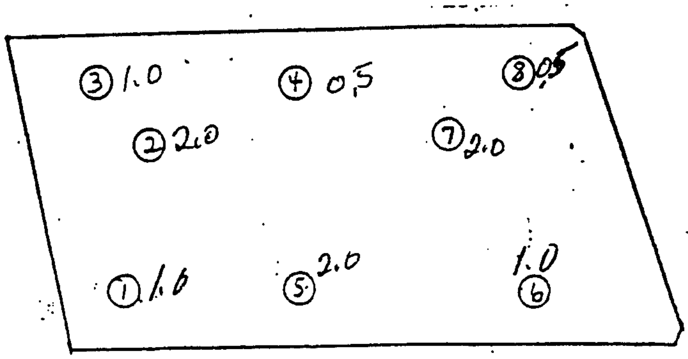
AIR & DeLam Located All Around Unit

Surface SCR Located Bottom Aft Edge of Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 88-H-02-08-436

	Value	Acc/Rej	Date	Inspector
Bus to Bus Resistance:	42.8 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.308	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to S.E.:		Acc	JUN 04 1993	22 PPG 77
S.E. to Metal:		Acc		
S.E. to S.E.:				
Nesa Scratch Test (350 VAC):	92.8 Ra 7+16H	A	JUN 09 1993	22 PPG 39
Light Transmittance:	73.6	A	JUN 09 1993	22 PPG 39
Haze:	2.3	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 0.5 3: 2.0 4: 1.0
5: 0.5 6: 0.5 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.090 2: 1.100 3: 1.100 4: 1.102
5: 1.102 6: 1.102 7: 1.102 8: 1.104
9: 1.102 10: 1.100 11: 1.104 12: 1.100

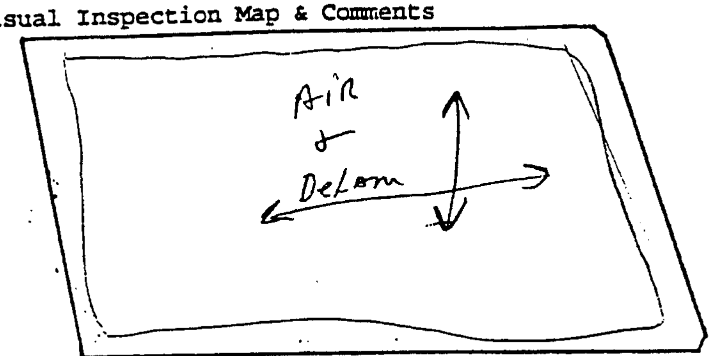
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) Seal Needs cutting Break on Outbd Side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

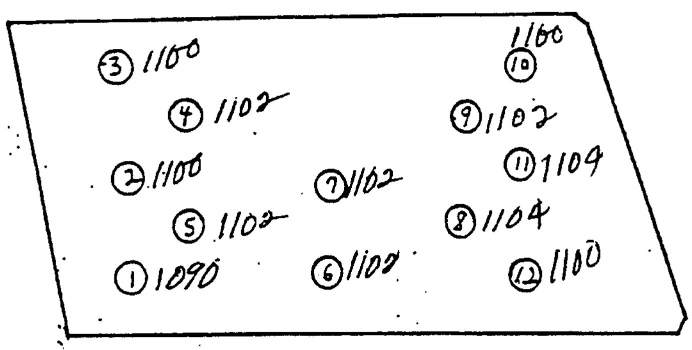
Check for vinyl cracks JUN 04 1993

Visual Inspection Map & Comments

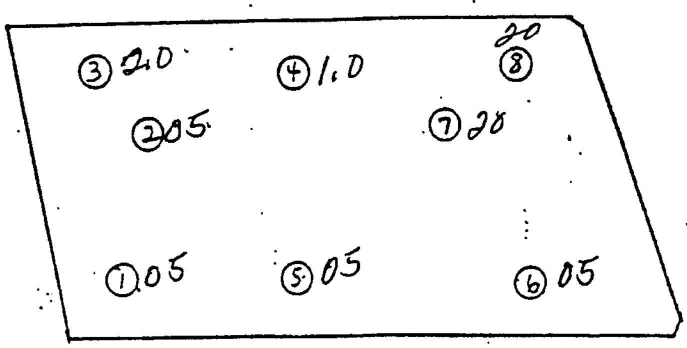


AiR And DeLAm LOCATed ALL ARound The UNiT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-12-6-431

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	43.8 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	314	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc	MAY 25 1993	22 PPG 77
Light Transmittance:		82.5	MAY 25 1993	22 PPG 77
Haze:		1.2	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-24-93	22 PPG 28

1: 2.0 2: 2.0 3: 2.0 4: 2.0
5: 2.0 6: ~~2.0~~ 1.0 E.L. 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-24-93	22 PPG 28

E.L.
1: 1.062 2: 1.061 3: 1.063 4: 1.066
5: 1.063 6: 1.063 7: 1.067 8: 1.063
9: 1.063 10: 1.062 11: 1.062 12: 1.063

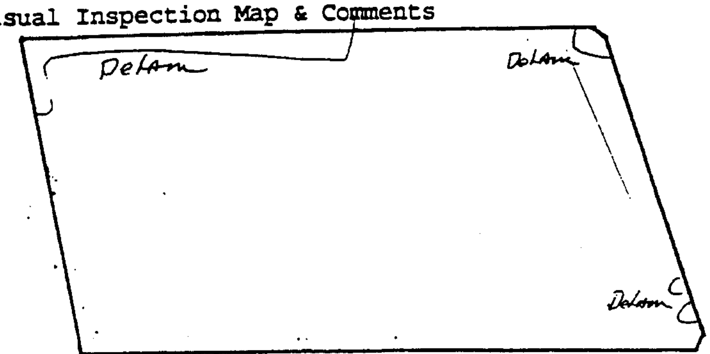
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) ______________________

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	ReJ	JUN 02 1993	22 PPG 77

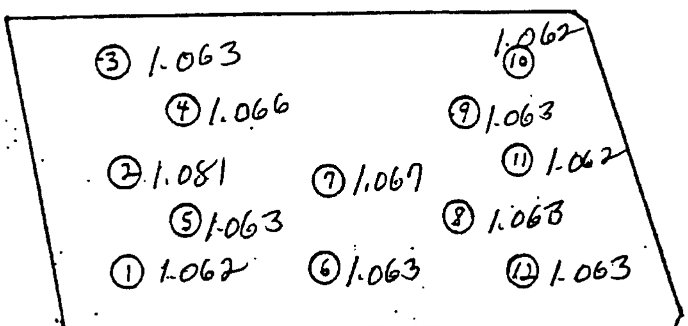
Check for vinyl cracks   Age   6-3-93

Visual Inspection Map & Comments

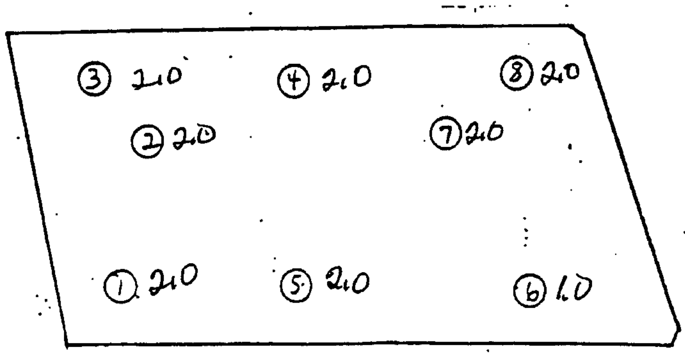


DelAm Alone TOP And Aft. Edge of Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 1-H-10-5-480

	Acc/Rej	Date	Inspector
✓ Bus to Bus Resistance: 42.2 Ohms		5-21-93	22 PPG 28
✓ Thermal Image:		5-19-93	22 PPG 23
✓ S.E. Resistance:	Acc	5-24-93	[illegible]
Insulation Test: (2500 VAC) Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
S.E. to Metal:	Acc		
S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):	Acc	MAY 25 1993	22 PPG 77
Light Transmittance:	82.6	MAY 25 1993	22 PPG 77
Haze:	1.2	MAY 25 1993	22 PPG 77
Photo (Single Exposure):		MAY 26 1993	22 PPG 4
✓ Deviation Inspection: (German Light per Template)	Acc	5-24-93	[illegible]

1: 2.0 2: 3.0 3: 2.0 4: 2.0
5: 0.5 6: 0.5 7: 1.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
✓ Unit Thickness: (Per Template)	Acc	5-24-93	[illegible]

1: 1.103 2: 1.104 3: 1.105 4: 1.105
5: 1.108 6: 1.104 7: 1.109 8: 1.104
9: 1.104 10: 1.105 11: 1.108 12: 1.105

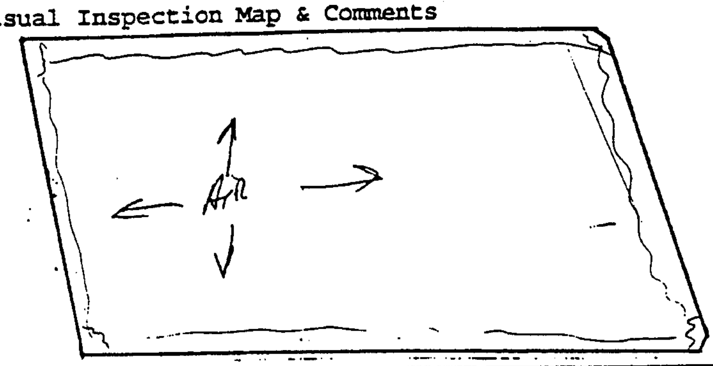
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments)
wrong seal on outbd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 02 1993	22 PPG 77

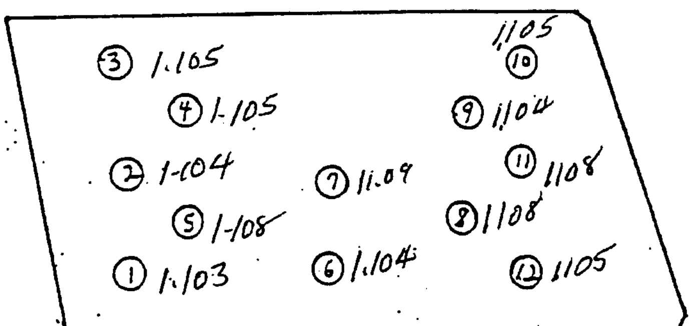
Check for vinyl cracks Acc 6-3-93 PPG 77

Visual Inspection Map & Comments

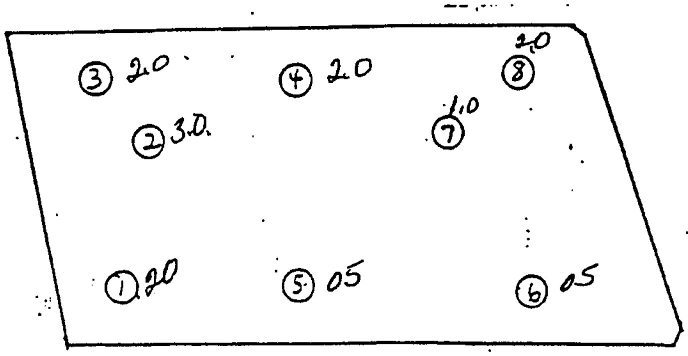


Air All Alone The edge of unit.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-9-19-294

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	50.8 Ohms		5-21-93	22 PPG 22
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.314	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	PG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	0165 1/5 52.L N/S	Lenth Hit Rej	JUN 09 1993	22 PPG 39
Light Transmittance:	77.0	A	JUN 09 1993	22 PPG 39
Haze:	1.7	A	JUN 09 1993	22 PPG 35
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 2.0 2: 2.0 3: 2.0 4: 1.0
5: 2.0 6: 2.0 7: 3.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.099 2: 1.099 3: 1.099 4: 1.100
5: 1.104 6: 1.106 7: 1.105 8: 1.102
9: 1.105 10: 1.102 11: 1.102 12: 1.096

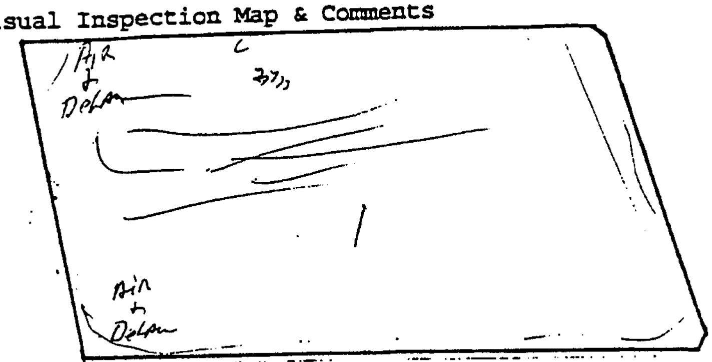
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) UNIT APPEARS TO BE Coming apart

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

Check for vinyl cracks Res JUN 04 1993 22 PPB

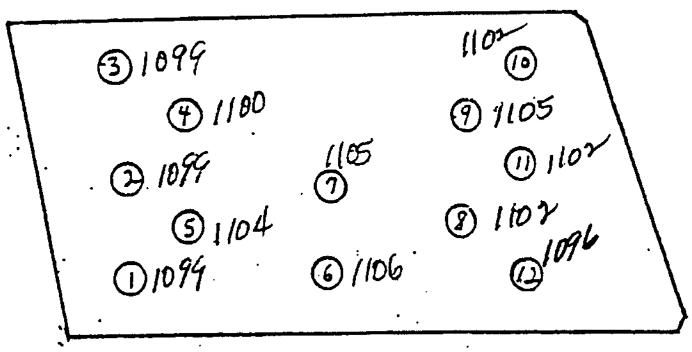
Visual Inspection Map & Comments



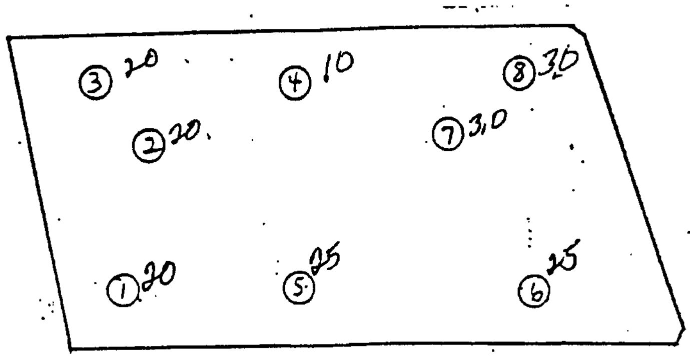
AIR And DeLam AROUND The unit.

SURface ~~CR~~ ALL OVER The OUTside side of unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-9-6-537

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	H2.1 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	3/2	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	437 Deg HIGH	A	JUN 09 1993	22 PPG 39
Light Transmittance:	74.2	A	JUN 09 1993	22 PPG 39
Haze:	1.2	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-26-93	22 PPG 28

1: 0.5 2: 1.0 3: 0.5 4: 1.0
5: 2.0 6: 0.5 7: 1.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

1: 1.124 2: 1.124 3: 1.119 4: 1.124
5: 1.126 6: 1.120 7: 1.120 8: 1.124
9: 1.120 10: 1.122 11: 1.122 12: 1.118

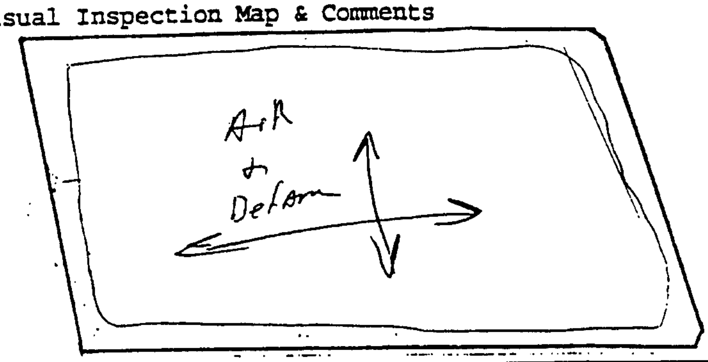
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04	22

(Comments) wrong seal on outbd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

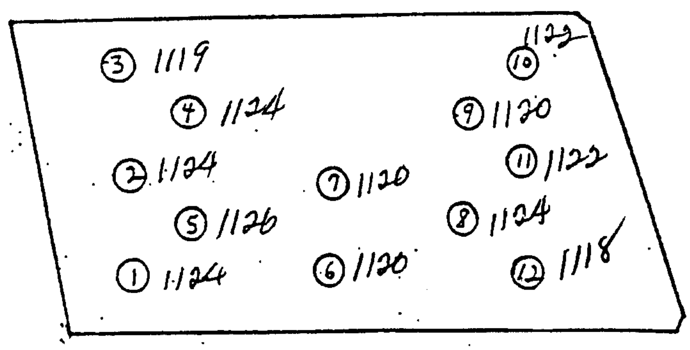
Check for vinyl cracks Acc JUN 04 1993 22 PP6 77

Visual Inspection Map & Comments

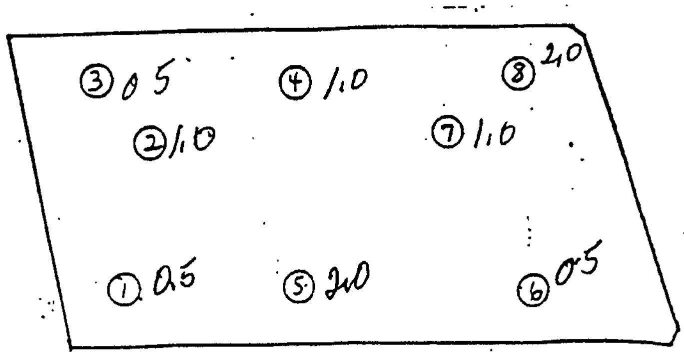


AiR + DeLam LocATed ALL ARound UNiT.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-9-19-459

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.2 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.313	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	42.3 Dist. Fwd + Aft (Swz) center	A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.8	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 2.0 2: 1.0 3: 1.0 4: 2.0
5: 1.0 6: 0.5 7: 4.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.102 2: 1.099 3: 1.102 4: 1.101
5: 1.102 6: 1.109 7: 1.102 8: 1.102
9: 1.102 10: 1.106 11: 1.101 12: 1.100

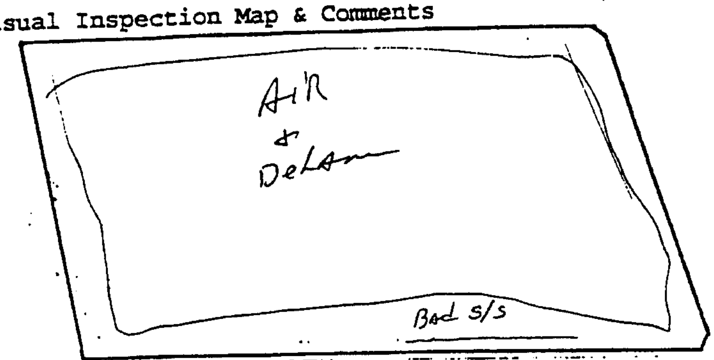
	Acc/Rej	Date	Inspector
Seal Evaluation:	Res	JUN 04 1993	22 PPG 77

(Comments) Seal needs cutting too size

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 04 1993	22 PPG 77

Check for vinyl cracks ALC JUN 04 1993

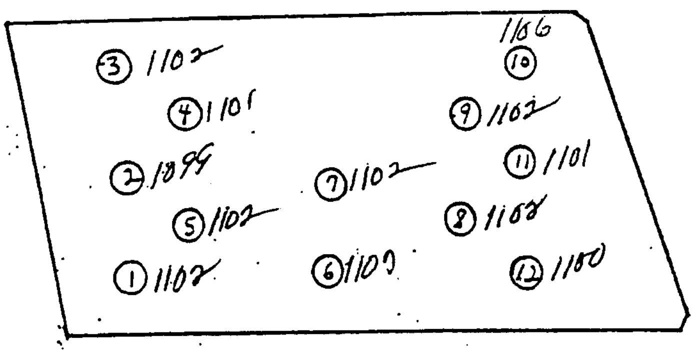
Visual Inspection Map & Comments



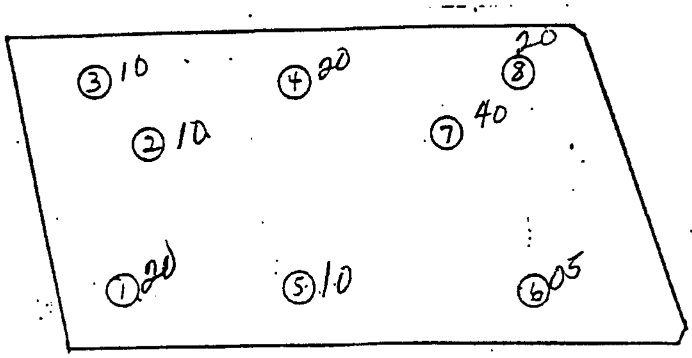
AiR & DeLam Located Around The unit.

Very Bad surface scr Located Bottom front Edge

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89364-502

Unit Serial Number: 86-11-10-06-007

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	37.5 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-21-93	22 PPG 28
S.E. Resistance:	308	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	All ok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	All ok		
	S.E. to S.E.:	All ok		
Nesa Scratch Test (350 VAC):		All ok	MAY 25 1993	22 PPG 77
Light Transmittance:		86.3	MAY 25 1993	22 PPG 77
Haze:		1.4	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 25 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 1.0 3: 3.0 4: 1.0
5: 0.5 6: 1.0 7: 2.0 8: 0.5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-25-93	22 PPG 28

1: 1.097 2: 1.095 3: 1.091 4: 1.095
5: 1.095 6: 1.094 7: 1.093 8: 1.093
9: 1.096 10: 1.097 11: 1.093 12: 1.091

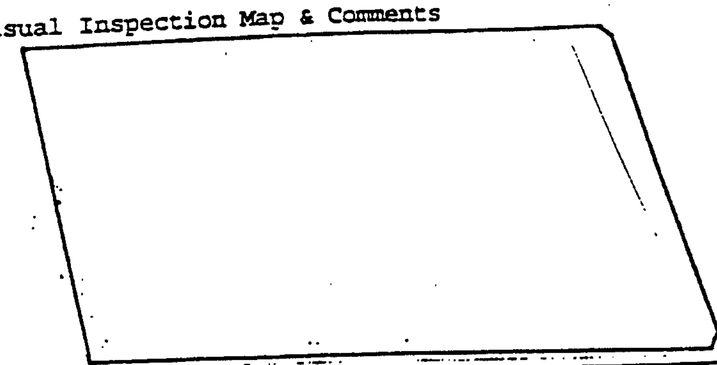
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments)

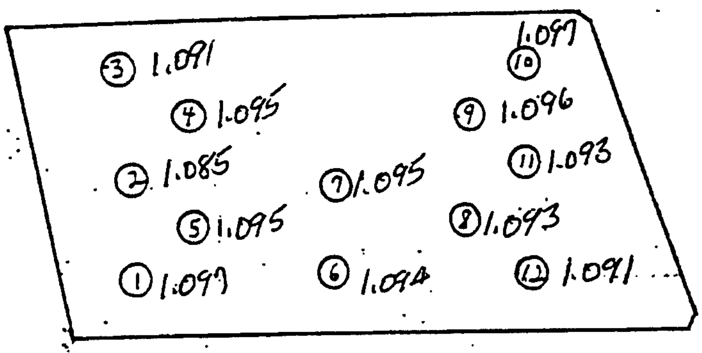
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks 6-3-93

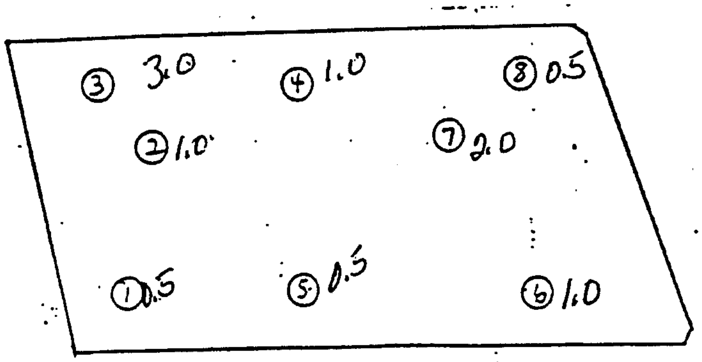
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-030

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	34.8 Ohms	Acc.	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	312	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	AOK	MAY 25 1993	22 PPG 77
	S.E. to Metal:	AOK		
	S.E. to S.E.:	AOK		
Nesa Scratch Test (350 VAC):		AOK	MAY 25 1993	22 PPG 77
Light Transmittance:		77.3	MAY 25 1993	22 PPG 77
Haze:		1.3	MAY 25 1993	22 PPG 77
Photo (Single Exposure):				
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 0.5 2: 3.0 3: 2.0 4: 1.0
5: 0.5 6: 0.5 7: 1.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:		MAY 25 1993	22 PPG 4
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.093 2: 1.095 3: 1.095 4: 1.008
5: 1.097 6: 1.095 7: 1.098 8: 1.098
9: 1.097 10: 1.097 11: 1.095 12: 1.095

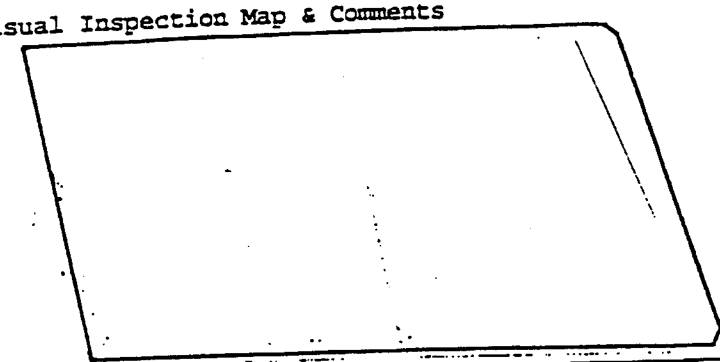
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments) ______________________

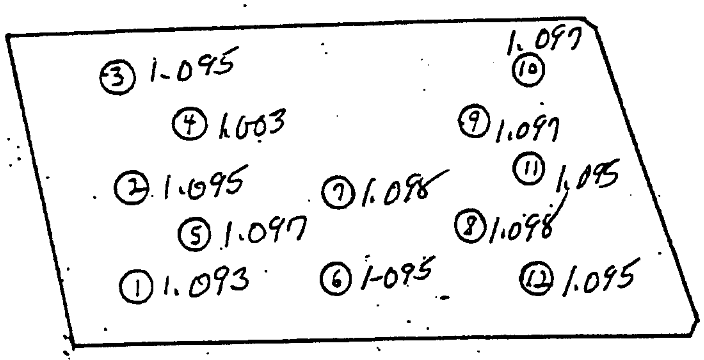
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks   Acc 6-3-83 22 PP8 77

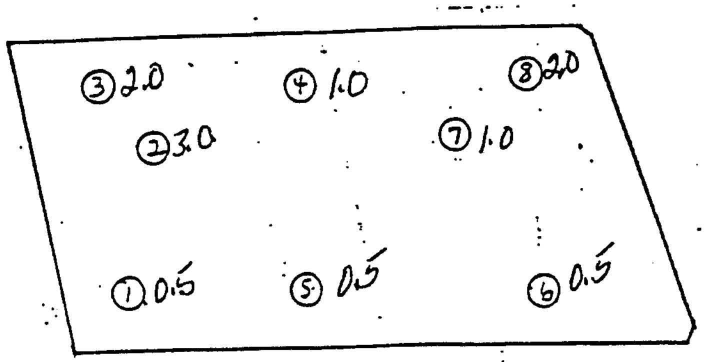
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-022

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	33.6 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	314	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	ok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	ok		
	S.E. to S.E.:	ok		
Nesa Scratch Test (350 VAC):		ok	MAY 25 1993	22 PPG 77
Light Transmittance:		78.6	MAY 25 1993	22 PPG 77
Haze:		1.3	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 25 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 EPG 28

1: 0.5 2: 0.0 3: 1.0 4: 0.0
5: 0.5 6: 1.0 7: 2.0 8: 2.0

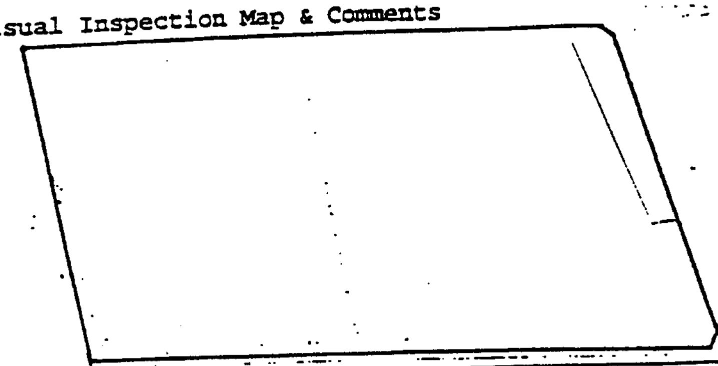
		Acc/Rej	Date	Inspector
Dimensional Inspection:				
Unit Thickness: (Per Template)		Acc	5-25-93	22 EPG 28

1: 1.000 2: 1.097 3: 1.095 4: 1.090
5: 1.098 6: 1.004 7: 1.105 8: 1.103
9: 1.105 10: 1.102 11: 1.098 12: 1.100

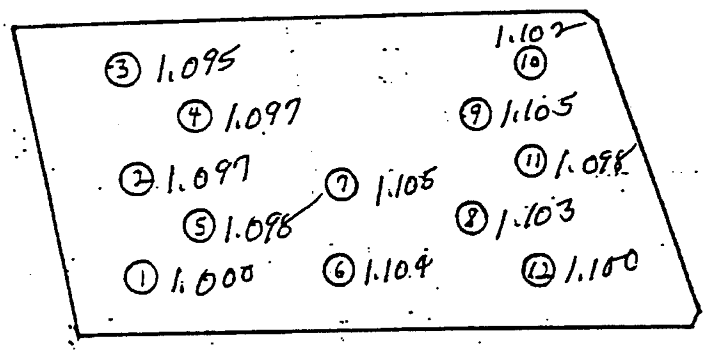
		Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)		Acc	JUN 02 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)		Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks 6-393 22 PPS

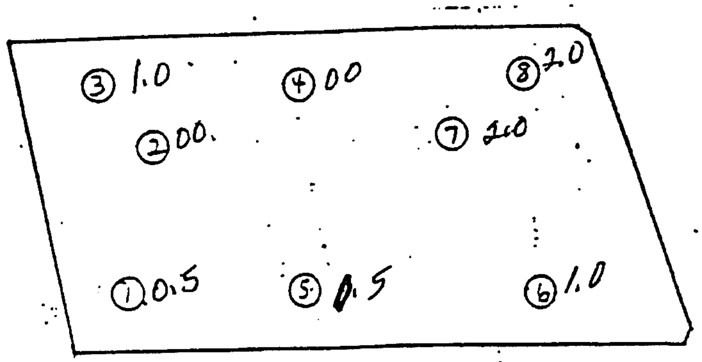
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-502

Unit Serial Number: 86-H-10-06-096

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	33.5 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	308	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc ok	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc ok		
	S.E. to S.E.:	Acc ok		
Nesa Scratch Test (350 VAC):		Acc ok	MAY 25 1993	22 PPG 77
Light Transmittance:		77.8	MAY 25 1993	22 PPG 77
Haze:		1.3	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 2 5 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc 5-25-93	5-25-93	22 PPG 22

1: 2.0 2: 2.0 3: 2.0 4: 2.0
5: 0.5 6: 1.0 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc 5-25-93	5-25-93	22 PPG 28

1: 1.098 2: 1.100 3: 1.105 4: 1.105
5: 1.099 6: 1.103 7: 1.105 8: 1.105
9: 1.108 10: 1.105 11: 1.100 12: 1.103

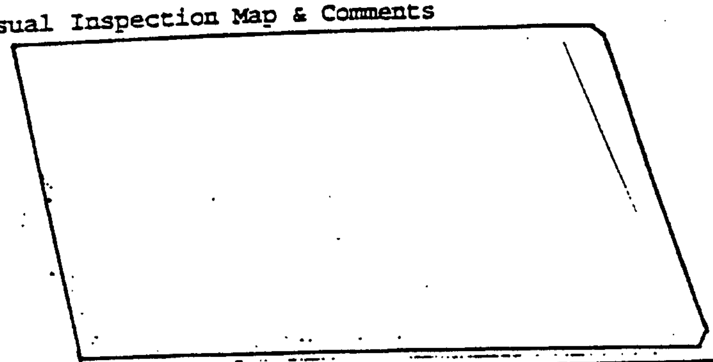
	Acc/Rej	Date	Inspector
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

(Comments)

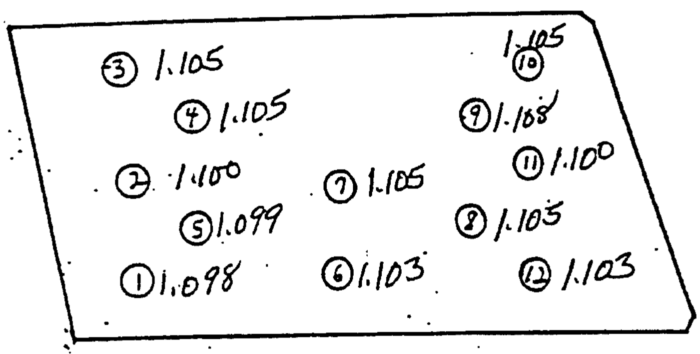
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

Check for vinyl cracks Aac 6-3-83 22 P[illegible]77

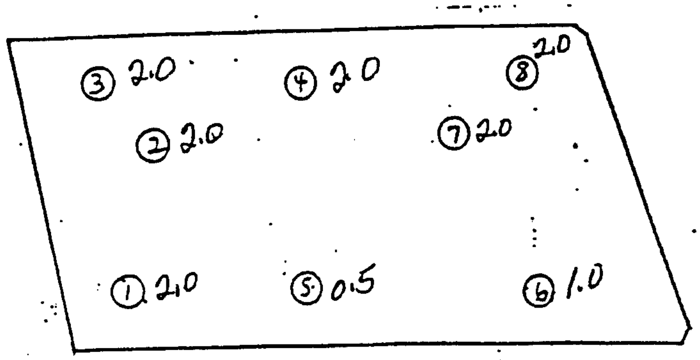
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-9-19-282

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.7 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-19-93	22 PPG 28
S.E. Resistance:	314	Acc.	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc		
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc		
Light Transmittance:		82.3		
Haze:		1.1		
Photo (Single Exposure):			MAY 2 6 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc.	5-24-93	22 PPG 28

1: 3.0 2: 3.0 3: 3.0 4: 1.0
5: 1.0 6: 1.0 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-24-93	22 PPG 28

1: 1.094 2: 1.095 3: 1.096 4: 1.100
5: 1.002 6: 1.002 7: 1.105 8: 1.100
9: 1.101 10: 1.097 11: 1.100 12: 1.097

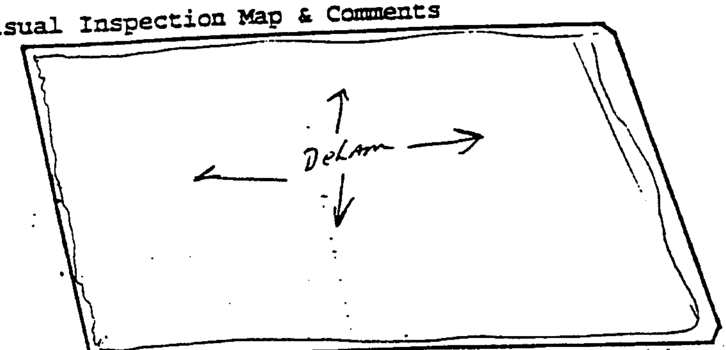
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 0 2 1993	PPG 77

(Comments) Wrong seal on outbd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 2 1993	22 PPG 77

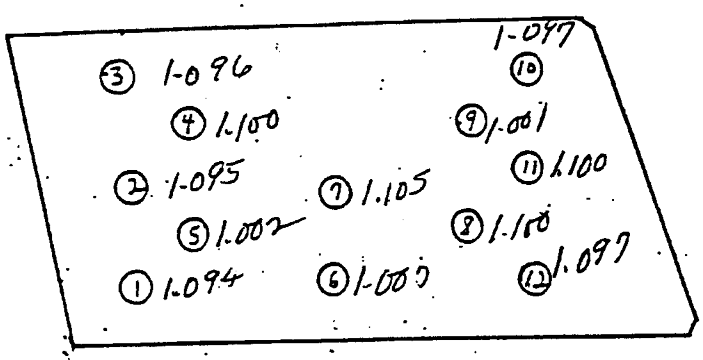
Check for vinyl cracks Ade 6-3-93 PPG 77

Visual Inspection Map & Comments

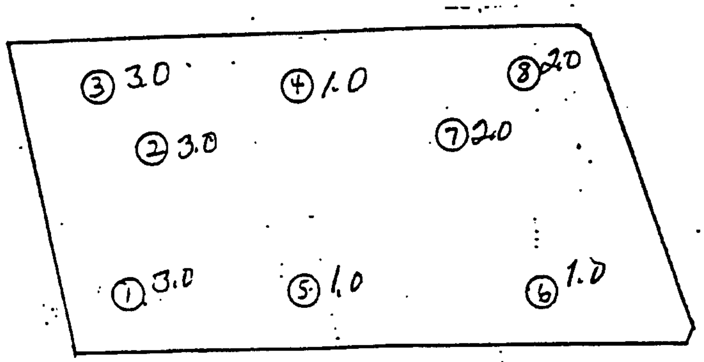


DeLam Located All Around the Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-8-15-756

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	46.0 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-19-93	22 PPG 22
S.E. Resistance:	.313	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc	MAY 25 1993	22 PPG 77
Light Transmittance:		80.7	MAY 25 1993	22 PPG 77
Haze:		1.0	MAY 25 1993	22 PPG 77
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5-24-93	22 PPG 28

1: 2.0 2: 0.5 3: 1.0 4: 1.0
5: 0.5 6: 0.5 7: 2.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-24-93	22 PPG 28

1: 1.077 2: 1.082 3: 1.084 4: 1.085
5: 1.085 6: 1.085 7: 1.087 8: 1.085
9: 1.087 10: 1.086 11: 1.085 12: 1.085

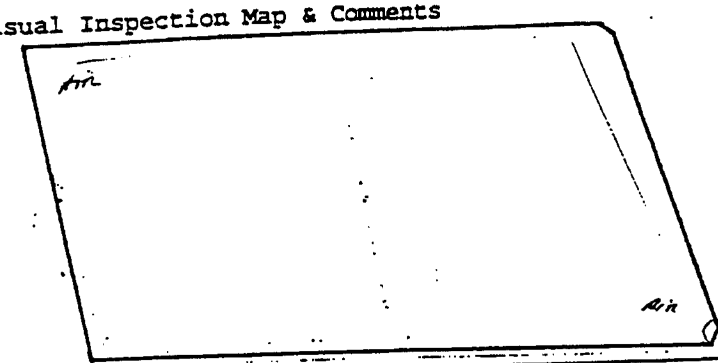
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments) wrong seal on outbd. side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 79

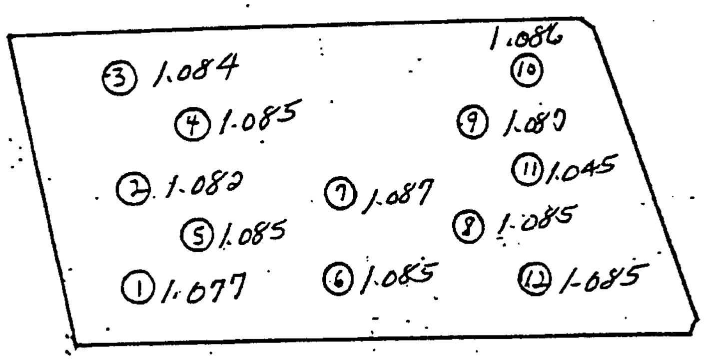
Check for vinyl cracks Ace 6-3-93 22 PPG 77

Visual Inspection Map & Comments

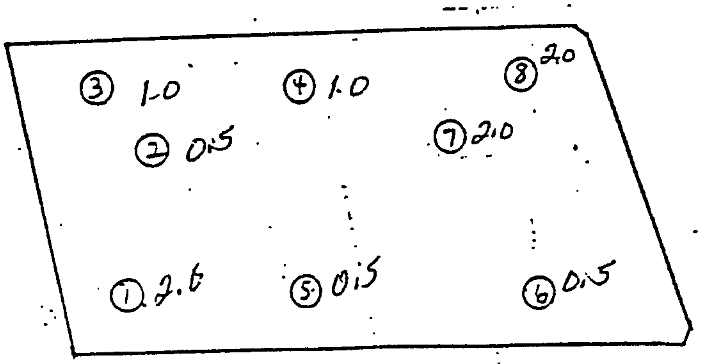


Air starting along edge of unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 84-H-3-19-220

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	44.5 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	316	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.: 146 Ms			
Nesa Scratch Test (350 VAC):	Unit center 46.1	A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.3	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 1.0 2: 2.0 3: 2.0 4: 0.5
5: 0.5 6: 2.0 7: 1.0 8: 2.0

		Acc/Rej	Date	Inspector
Dimensional Inspection:				
Unit Thickness: (Per Template)		Acc	5-25-93	22 PPG 28

1: 1.093 2: 1.090 3: 1.089 4: 1.094
5: 1.094 6: 1.092 7: 1.096 8: 1.091
9: 1.092 10: 1.091 11: 1.091 12: 1.093

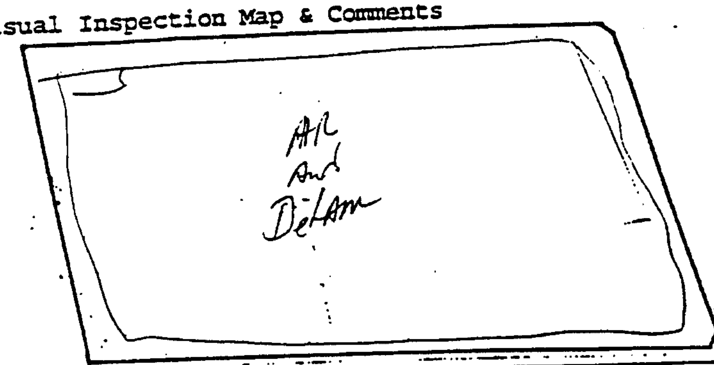
		Acc/Rej	Date	Inspector
Seal Evaluation:		Rej	JUN 04 1993	22 PPG 77

(Comments) Seal Needs cutting

		Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)		Rej	JUN 04 1993	22 PPG 77

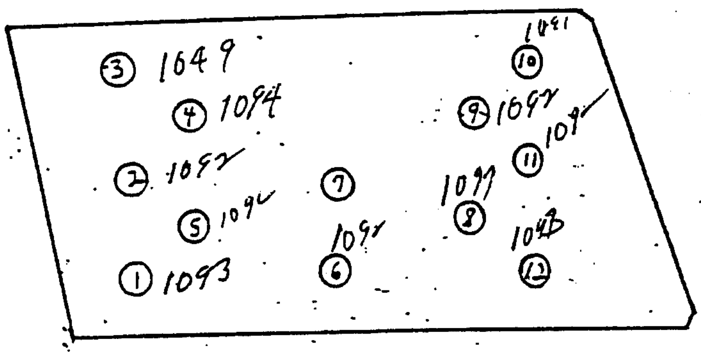
Check for vinyl cracks [signature] JUN 04 1993 22 PP8 77

Visual Inspection Map & Comments

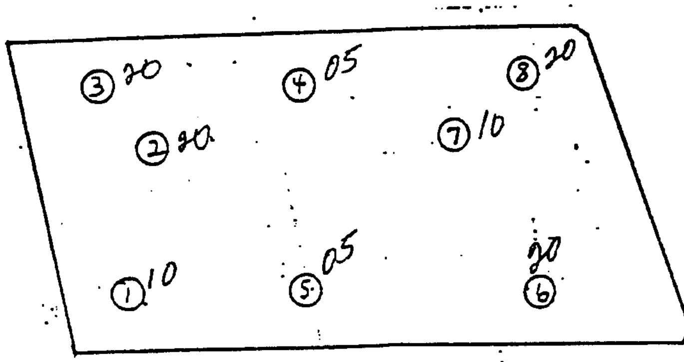


UNIT HAS AIR/DeLAm LOCATED THROUGHOUT.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: S-84354-501

Unit Serial Number: 86-H-12-01-146

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	36.5 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-21-93	22 PPG 28
S.E. Resistance:	309	Acc	5-24-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	MAY 25 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:	Acc		
Nesa Scratch Test (350 VAC):		Acc	MAY 25 1993	22 PPG 77
Light Transmittance:		81.0	MAY 25 1993	22 PPG 77
Haze:		.8	MAY 25 1993	22 PPG 28
Photo (Single Exposure):			MAY 26 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	5.24-93	22 PPG 28

1: 3.0 2: 3.0 3: 2.0 4: 4.0
5: 2.0 6: 0.5 7: 4.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:		~~MAY 26 1993~~	~~22 PPG 4~~ VOID 5-26-93 Rec
Unit Thickness: (Per Template)	Acc	5-24-93	22 PPG 28

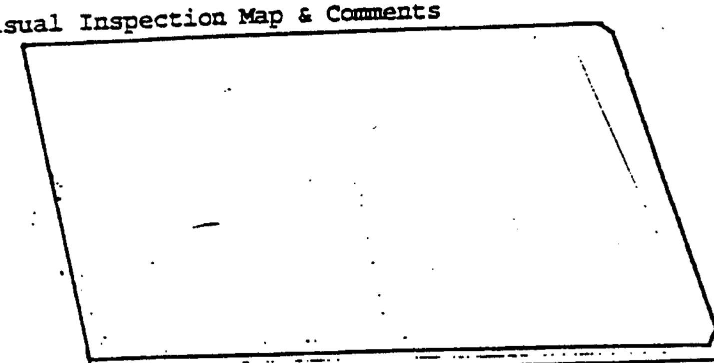
1: 1.093 2: 1.094 3: 1.095 4: 1.098
5: 1.094 6: 1.101 7: 1.102 8: 1.100
9: 1.098 10: 1.099 11: 1.103 12: 1.101

	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments) wrong seal on outbd	Rej	JUN 02 1993	22 PPG 77
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

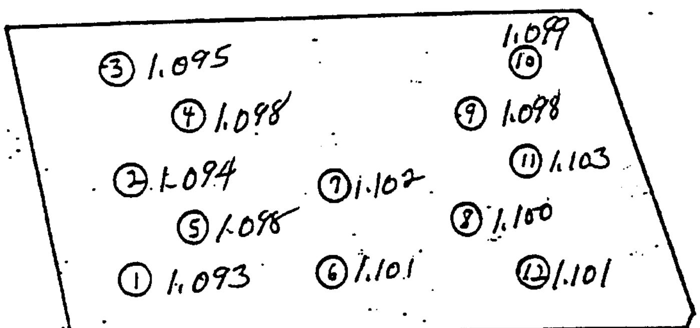
Ace 6-393

Check for vinyl cracks

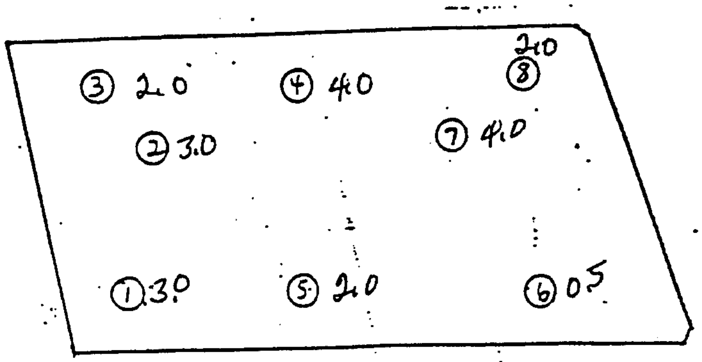
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-10-18-107

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	41.3 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.311	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	40.8 DIST FWD Center & Lower	A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.8	A	JUN 09 1993	22 PPG 39
Haze:	.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc	5-25-93	22 PPG 28

1: 3.0 2: 3.0 3: 2.0 4: 0.5
5: 2.0 6: 1.0 7: 2.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.093 2: 1.089 3: 1.093 4: 1.094
5: 1.095 6: 1.096 7: 1.096 8: 1.096
9: 1.095 10: 1.091 11: 1.090 12: 1.092

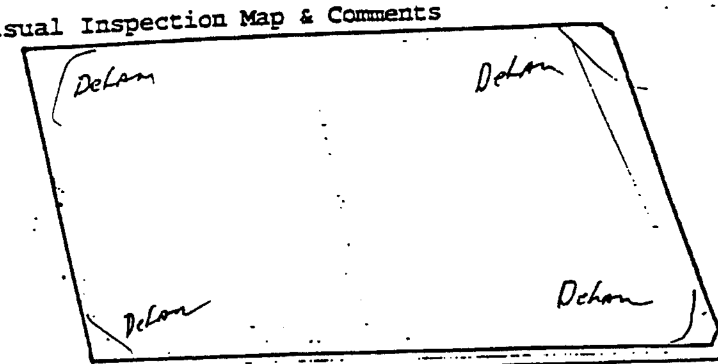
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

(Comments) Seal Needs cutting to size

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

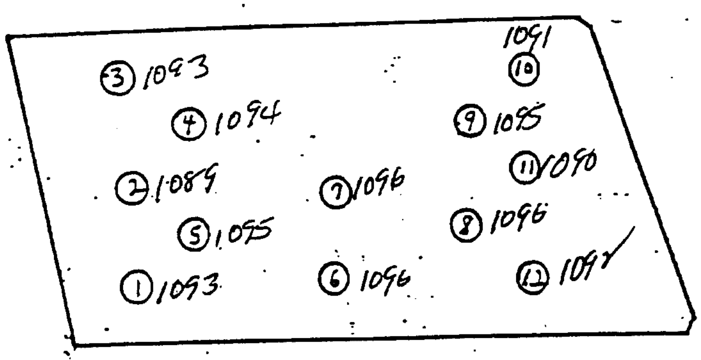
Check for vinyl cracks JUN 04 1993

Visual Inspection Map & Comments

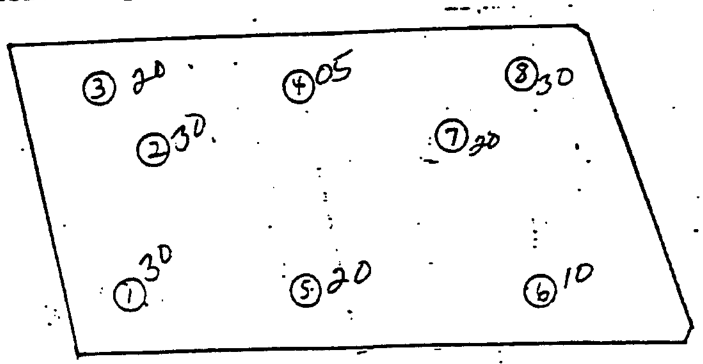


DeLam Located in All Four Corner

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 82-H-9-6-235

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	43.4 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	.311	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC) TOPFWD	Power to S.E.:	Acc		
	S.E. to Metal:	Acc		
	S.E. to S.E.:	✓		
Nesa Scratch Test (350 VAC): S/S AIR ATTRUP S/E	Res High 447	A	JUN 09 1993	22 PPG 39
Light Transmittance:	74.8	A	JUN 09 1993	22 PPG 39
Haze:	.13	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Acc 5-26-9	5-26-93	22 PPG 28

1: 2.0 2: 2.0 3: 2.0 4: 1.0
5: 0.5 6: 2.0 7: 2.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc	5-26-93	22 PPG 28

1: 1.090 2: 1.093 3: 1.090 4: 1.091
5: 1.094 6: 1.097 ✓ 7: 1.097 8: 1.095
9: 1.095 10: 1.090 11: 1.091 12: 1.085

	Acc/Rej	Date	Inspector
Seal Evaluation: (Comments)	Rej	JUN 04 1993	22 PPG 77

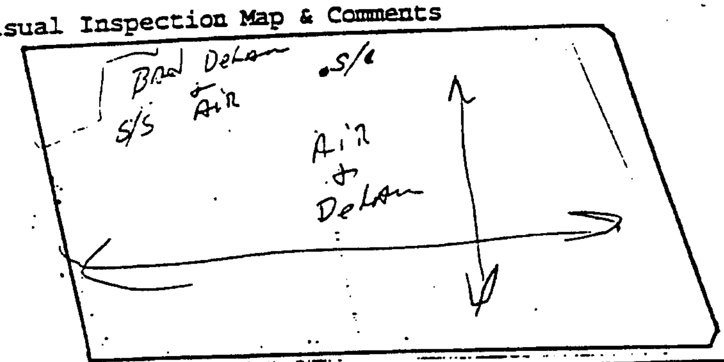
Seal Needs Cutting on Outbd Side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 04 1993	22 PPG 77

Check for vinyl cracks

ACC JUN 04 1993

Visual Inspection Map & Comments

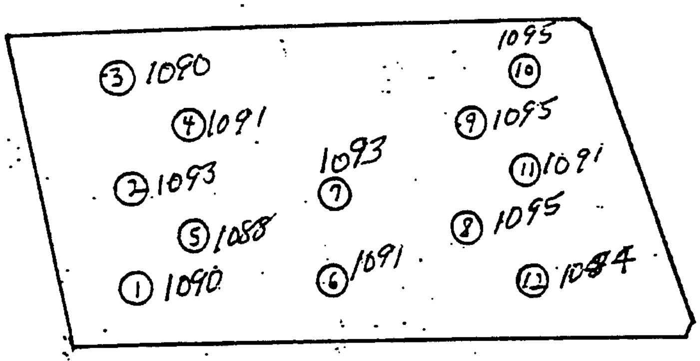


Air And DeLam LOCATed All Around Unit

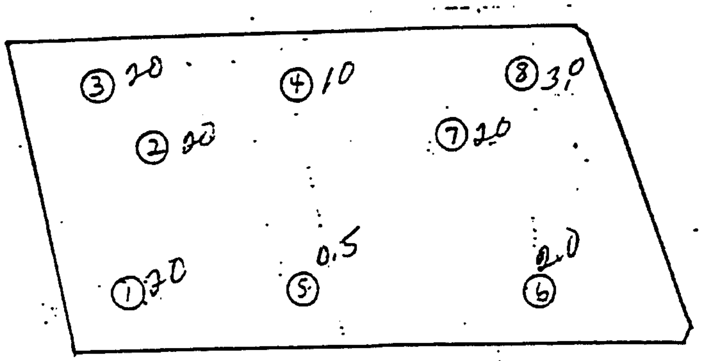
Surface SCR LOCATed As marked

Surface chip LOCATed As marked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 83-H-11-21-325

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	45.7 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	313	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 39
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	17.0 Res HIGH	A	JUN 09 1993	22 PPG 39
Light Transmittance:	73.7	A	JUN 09 1993	22 PPG 39
Haze:	.8	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 28
Deviation Inspection: (German Light per Template)		Acc	1-25-93	22 PPG 28

1: 1.0 2: 2.0 3: 1.0 4: 1.0
5: 1.0 6: 0.5 7: 2.0 8: 3.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:	/		
Unit Thickness: (Per Template)	Acc	5-25-93	22 PPG 28

1: 1.090 2: 1.092 3: 1.093 4: 1.088
5: 1.090 6: 1.092 7: 1.090 8: 1.090
9: 1.088 10: 1.085 11: 1.089 12: 1.089

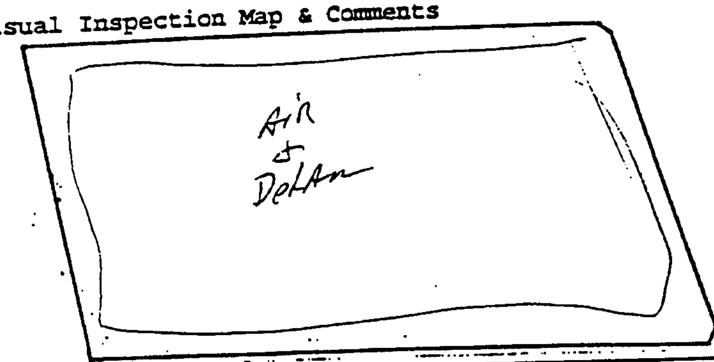
	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 39

(Comments) Seal Need To Be Trimed. Back

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 04 1993	22 PPG 39

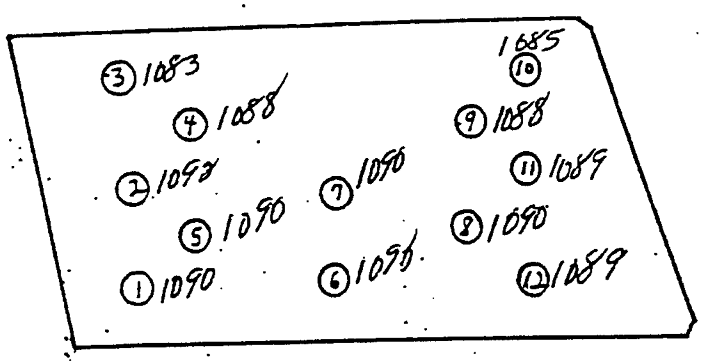
Check for vinyl cracks Aca JUN 04 1993 22 PP6.77

Visual Inspection Map & Comments

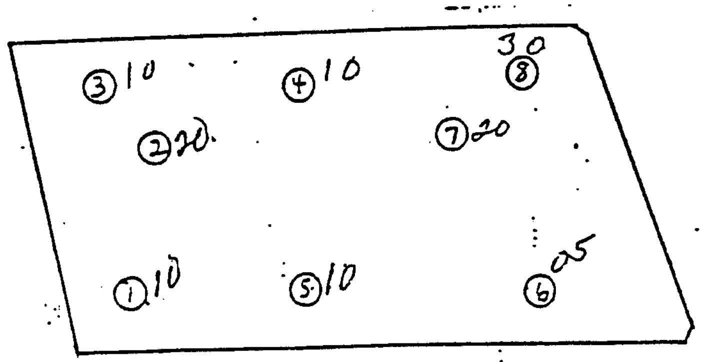


Air And Delam Located Around The Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot Main Windshield

Customer Part Number: 5-89354-501

Unit Serial Number: 89 286 ~~HO~~ H.O 697

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	38.0 Ohms	Acc	5-21-93	22 PPG 28
Thermal Image:			5-20-93	22 PPG 28
S.E. Resistance:	309	Acc	5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to S.E.:	Acc	JUN 04 1993	22 PPG 77
	S.E. to Metal:	Acc		
	S.E. to S.E.:			
Nesa Scratch Test (350 VAC):	37.7 DIST E/E	A	JUN 09 1993	22 PPG 39
Light Transmittance:	77.9	A	JUN 09 1993	22 PPG 39
Haze:	1.7	A	JUN 09 1993	22 PPG 39
Photo (Single Exposure):			JUN 14 1993	22 PPG 8
Deviation Inspection:		Acc	5-25-93	22 PPG 28

(German Light per Template)
1: 2.0 2: 3.0 3: 2.0 4: 3.0
5: 2.0 6: 0.5 7: 3.0 8: 2.0

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness:	Acc	5-25-93	22 PPG 28

(Per Template)
1: 1.080 2: 1.080 3: 1.085 4: 1.085
5: 1.080 6: 1.086 7: 1.083 8: 1.089
9: 1.089 10: 1.090 11: 1.086 12: 1.087

	Acc/Rej	Date	Inspector
Seal Evaluation:	Rej	JUN 04 1993	22 PPG 77

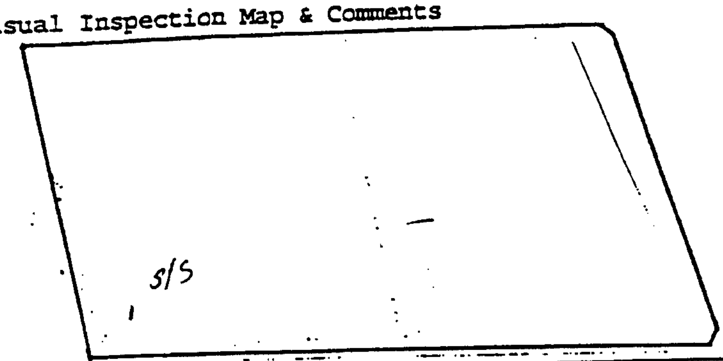
(Comments) Seal Needs cutting on OUTBd Side

	Acc/Rej	Date	Inspector
Visual Inspection:	Rej	JUN 04 1993	22 PPG 77

(Place comments on attached sheet)

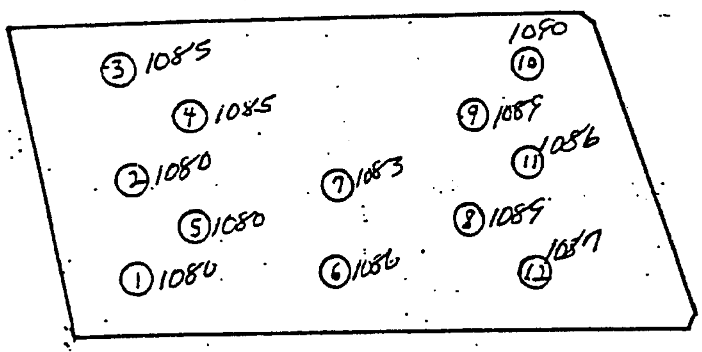
Check for vinyl cracks Ado JUN 04 1993 22 PPG 77

Visual Inspection Map & Comments

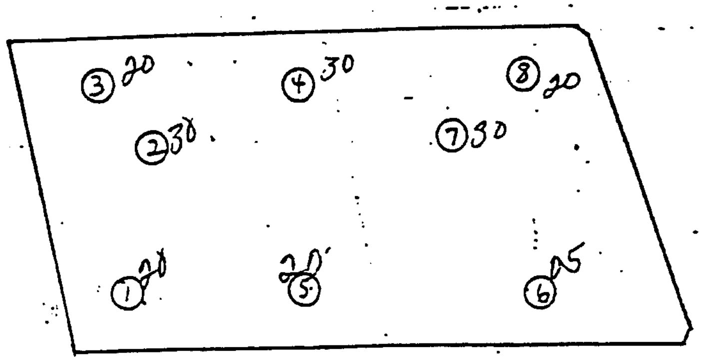


SURface ScR Located As MARked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-89357-1

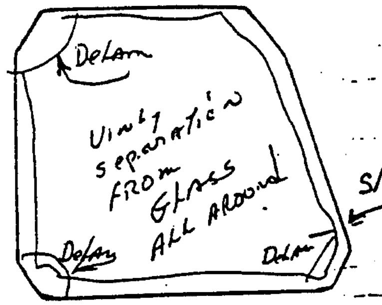
Unit Serial Number: B75-1149

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 71.1 Ohms	A	5-21-93	22PPG22
Thermal Image:		5-21-93	22PPG28
Insulation Test Power to Metal: (2500 VAC)	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.8	MAY 2 6 1993	22PPG43
Haze:	1.8	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <10 2: <10 3: <10 4: <10	Ac	JUN 0 9 1993	22 PPG 39
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .740 2: .741 3: .757 4: .740	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) Wrong Seal on outBd.

Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

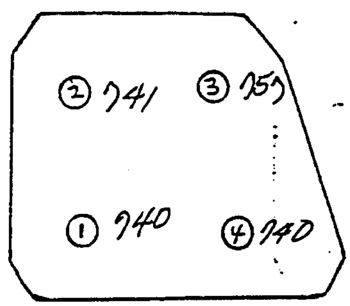
Visual Inspection Map & Comments



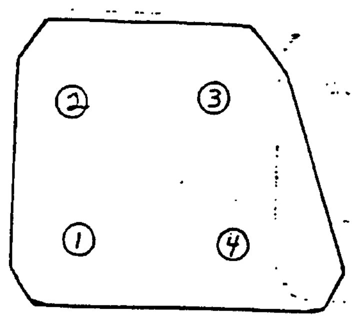
Vinly Separation from Glass Edge All Around
Unit inBd side.

DeLam Around unit in corner unit has
surface ser. Remover Between ply.

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

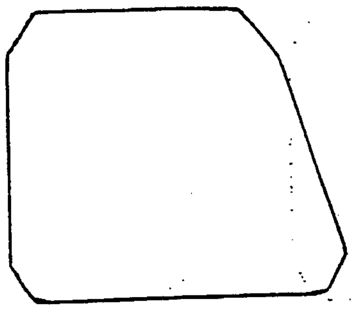
Unit Serial Number: 92 064 HO 471

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 69.8 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	79.7	MAY 26 1993	22 PPG 77
Haze:	1.5	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 3	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .698 2: .690 3: ~~.707~~ .697 4: .692	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

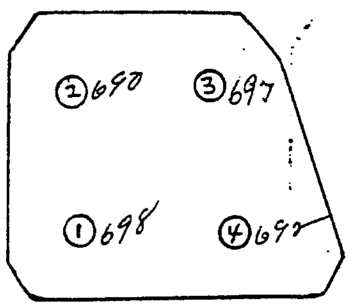
(Comments) ______________________________

Visual Inspection: (Place comments on attached sheet) — Acc — JUN 02 1993 — 22 PPG 77

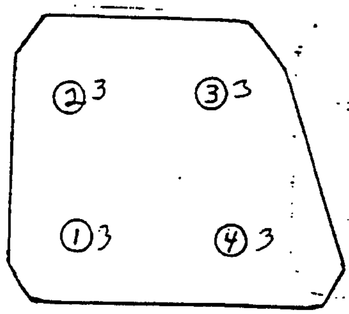
Visual Inspection Map & Comments



Thickness Template



Deviation Template



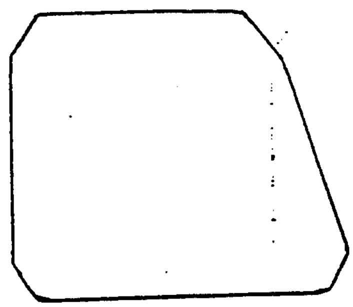
KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

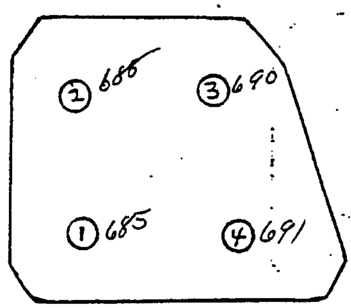
Unit Serial Number: 92-064-40-473

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 39.4 Ohms	Acc	5-24-93	22 PPG 22
Thermal Image:		5-24-93	22 PPG 22
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	79.9	MAY 26 1993	22 PPG 77
Haze:	1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 3	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .685 2: .688 3: .690 4: .691	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77
(Comments)			
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

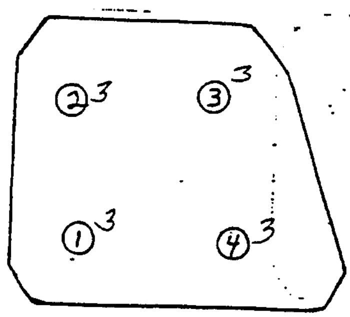
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

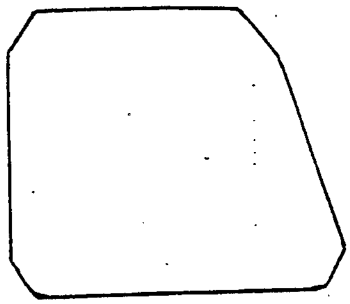
Unit Serial Number: 92 059 HO 350

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 70.1 ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	79.7	MAY 26 1993	22 PPG 77
Haze:	1.2	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 3 2: 3 3: 3 4: 3	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .689 2: .690 3: .691 4: .682	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

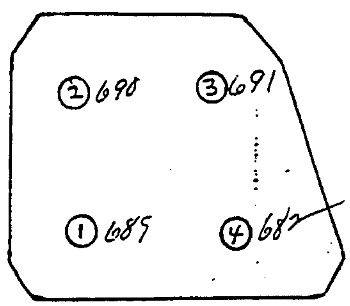
(Comments) ______________________________

Visual Inspection: (Place comments on attached sheet) — Acc — JUN 02 1993 — 22 PPG 77

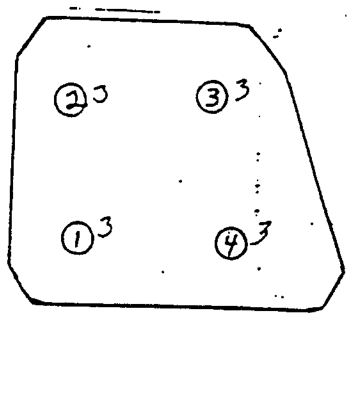
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

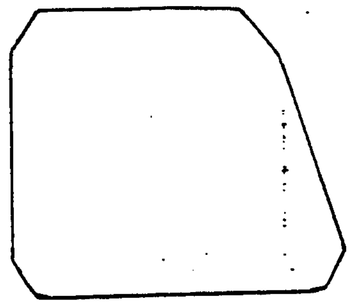
Unit Serial Number: 92-025-#0-006

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 69.3 Ohms	Acc	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.2	MAY 26 1993	22 PPG 77
Haze:	1.1	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 5 2: 3 3: 3 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .694 2: .693 3: .695 4: .690	Acc	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Acc	JUN 02 1993	22 PPG 77

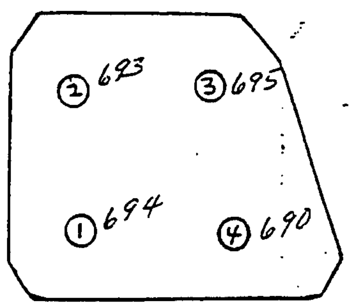
(Comments) ______________________________

Visual Inspection: (Place comments on attached sheet) — Acc — JUN 02 1993 — 22 PPG 77

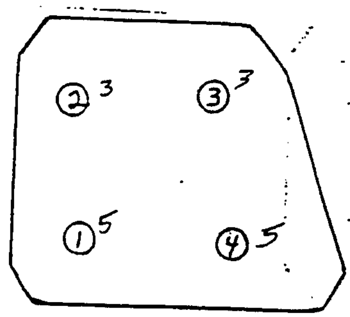
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

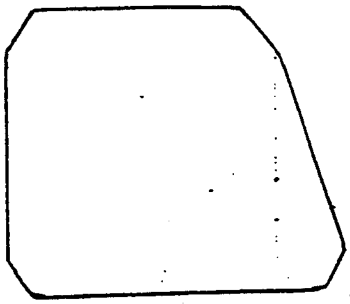
Unit Serial Number: 92-119 H0 186

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	64.8 ohms	Acc	9/2/93	22 PPG 15
Thermal Image:			9/2/93	
Insulation Test: (2500 VAC)	Power to Metal:	Acc	9/2/93	22 PPG 15
Nesa Scratch Test (81 VAC):		Acc	9/2/93	22 PPG 15
Light Transmittance:	81.5	Acc	9/2/93	[illegible]
Haze:	.9	Acc	9/2/93	[illegible]
Photo (Single Exposure):				
Deviation Inspection: (German Light per Template) 1: 5 2: 5 3: 3 4: 5		Acc	9/2/93	22 PPG 15
Dimensional Inspection:				
Unit Thickness: (Per Template) 1: .686 2: .686 3: .688 4: .688		Acc	9/2/93	22 PPG 15
Check for Vinyl Cracks:		Acc	9/2/93	22 PPG 15
Seal Evaluation:		Acc	9/2/93	22 PPG 15

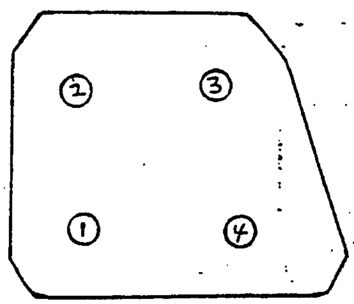
(Comments) ______________________________

Visual Inspection: (Place comments on attached sheet) Acc 9/2/93 22 PPG 15

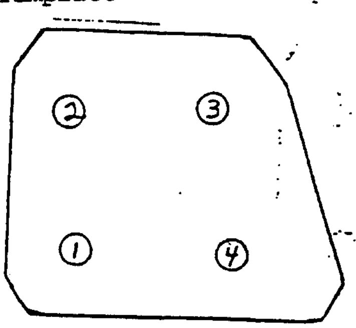
Visual Inspection Map & Comments



Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

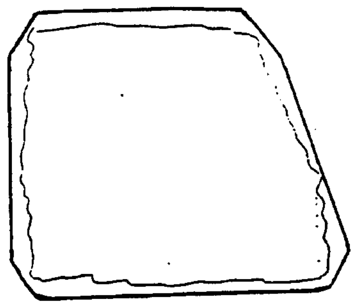
Unit Serial Number: 85-H-07-01-276

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: ______ Ohms	* ReJ	MAY 26 1993	22 PPG 77
Thermal Image:			
Insulation Test: (2500 VAC) Power to Metal:			
Nesa Scratch Test (81 VAC):	* ReJ	MAY 26 1993	22 PPG 77
Light Transmittance:	82.9	MAY 26 1993	22 PPG 77
Haze:	1.0	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 47
Deviation Inspection: (German Light per Template) 1: 4 2: 10 3: 7 4: 4	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: ~~.7__~~ .693 E.L. 2: .700 3: .695 4: .692			
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	ReJ	JUN 02 1993	22 PPG 77

(Comments) * OPEN CIRCUIT
WRONG SEAL ON OUTBD SIDE
INSIDE SEALANT

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	ReJ	JUN 02 1993	22 PPG 77

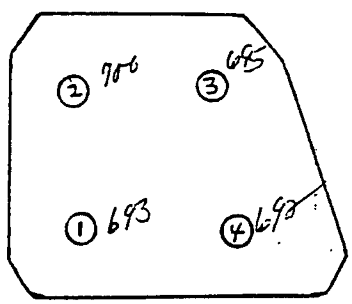
Visual Inspection Map & Comments



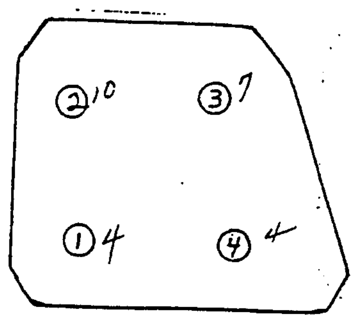
open Power Circuit

UNIT HAS AIR ALL ROUND THE UNIT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

Unit Serial Number: 90 173 HO 721

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	68.4 Ohms	Res ~~Acc~~ CAM 6-2-93	MAY 26 1993	22 PPG 77
Thermal Image:				
Insulation Test: (2500 VAC)	Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):		Acc	MAY 26 1993	22 PPG 77
Light Transmittance:		80.9	MAY 26 1993	22 PPG 77
Haze:		1.0	MAY 26 1993	22 PPG 77
Photo (Single Exposure):			MAY 2 8 1993	22 PPG 4
Deviation Inspection: (German Light per Template)		Acc	MAY 26 1993	22 PPG 77

1: 7 2: 7 3: 3 4: 5

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-25-93	22 PPG 28

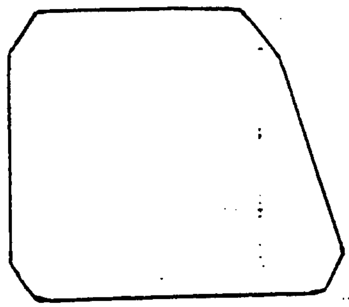
1: .646 2: .682 3: .688 4: .644

	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments) WRONG TYPE OF SEAL ON OUTBD SIDE ~~BAD Seal~~ OPEN CIRCUITS SOMETIME A READING AND OTHER TIMES NO READING

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Acc	JUN 02 1993	22 PPG 77

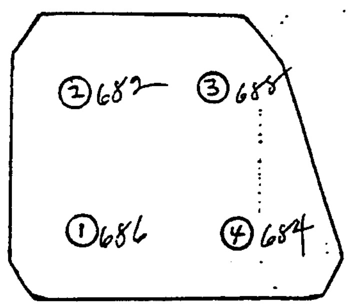
Visual Inspection Map & Comments



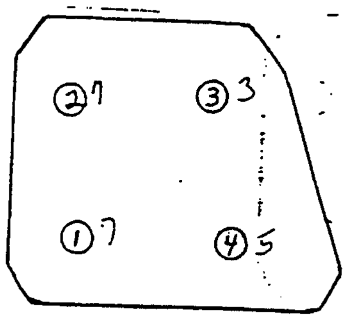
Open Power Circuit.

wrong type of seal on outbd side

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-13 Chg F

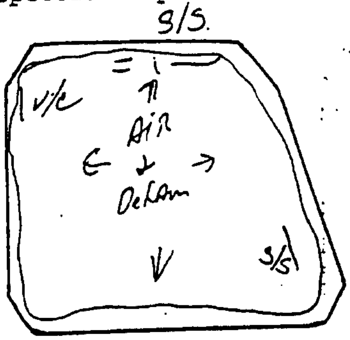
Unit Serial Number: 5-H-5-23-84

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 118.0 ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	80.7	MAY 26 1993	22PPG43
Haze:	.4	MAY 26 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: < 3 2: < 3 3: < 3 4: < 3	Acc	6-8-93	22 PPG 10
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .642 2: .643 3: .684 4: .686	Acc.	5-21-93	22 PPG 28
Check for Vinyl Cracks:	Rej.	JUN 03 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 03 1993	22 PPG 77

(Comments) BAd Seal + Bumper on outbd side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 03 1993	22 PPG 77

Visual Inspection Map & Comments

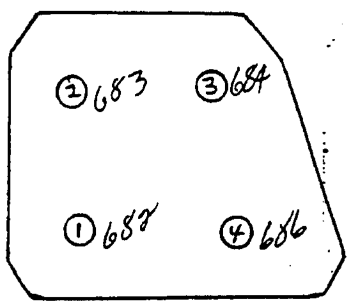


AiR & DeLam Located ALL ARound UNIT

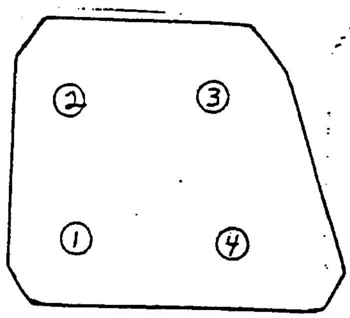
Vinly CRack Located AS marked

SURface SCR Located AS marked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501 Chg. H-

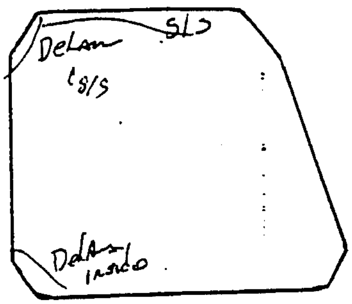
Unit Serial Number: 7-H-2-4-35

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 119.8 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc.	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	81.6	MAY 2 6 1993	22PPG43
Haze:	.9	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: ∠3 2: ∠3 3: ∠3 4: ∠3	Acc	6-8-93	22 PPG 10
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .696 2: .694 3: .692 4: .692	Acc.	5-26-93	22 PPG 28
Check for Vinyl Cracks:		JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) Bad Bumper

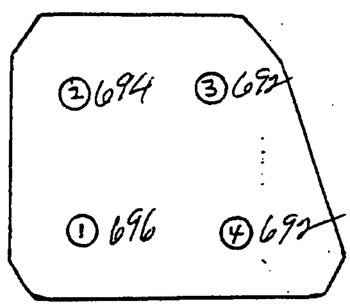
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

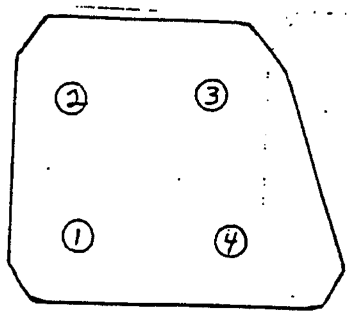


AIR And DeLAm located AROUND the edge
Surface Scr. located As marked

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764

Unit Serial Number: 4-H-10-9-69

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	85.0 Ohms		5-21-93	22 PPG 28
Thermal Image:			5-21-93	22 PPG 28
Insulation Test: (2500 VAC)	Power to Metal:	Acc.	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):		OK	MAY 26 1993	22PPG43
Light Transmittance:		82.2	MAY 26 1993	22PPG43
Haze:		1.0	MAY 26 1993	22PPG43
Photo (Single Exposure):		22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template)		Ac	6-8-93	22 PPG 10

1: < 3 2: < 3 3: < 3 4: < 3

	Acc/Rej	Date	Inspector
Dimensional Inspection:			
Unit Thickness: (Per Template)	Acc.	5-21-93	22 PPG 28

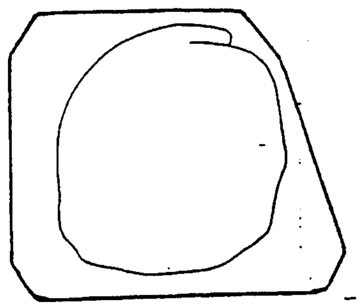
1: .677 2: .678 3: .679 4: .676

	Acc/Rej	Date	Inspector
Check for Vinyl Cracks:	Res	JUN 03 1993	22 PPG 77
Seal Evaluation:	Res	JUN 03 1993	22 PPG 77

(Comments) No Seal or Bumper

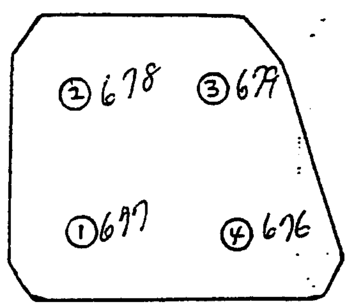
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 03 1993	22 PPG 77

Visual Inspection Map & Comments

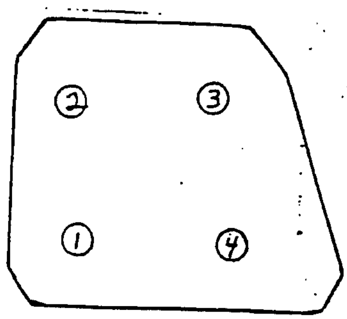


Air / Delam / Vinly Cracks Located All
Around Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

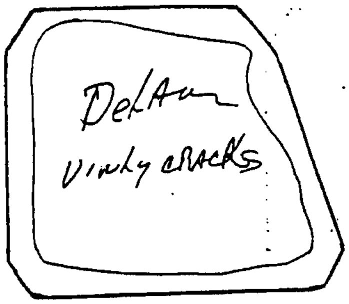
Unit Serial Number: 82-H-12-6-392

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 79.7 Ohms		5-21-93	82 [illegible]
Thermal Image:		5-21-93	82 [illegible]
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.3	MAY 2 6 1993	22PPG43
Haze:	1.0	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: 2.3 2: 24.5 3: 4.5 4: 7	Acc	6-8-93	22 PPG 10
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .666 2: .666 3: .668 4: .665	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Res	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Res	JUN 0 3 1993	22 PPG 77

(Comments) No seal or Bumper

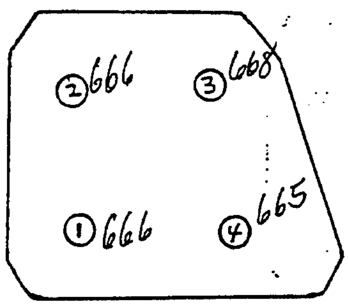
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Res	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

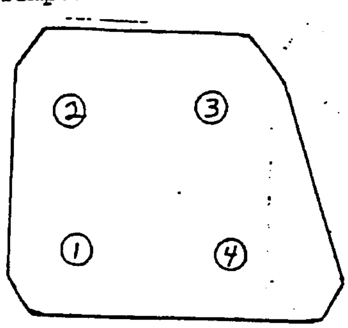


AIR, DeLam And Vinly cRacKS Located All ARound Unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

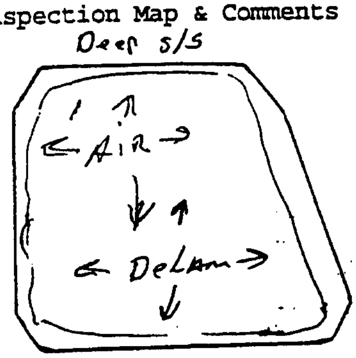
Unit Serial Number: 6-H-12-02-36

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 123.2 / 96.8 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.2	MAY 2 6 1993	22PPG43
Haze:	.8	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22PPG8
Deviation Inspection: (German Light per Template) 1: <3 2: <3 3: <3 4: <3	A	JUN 0 9 1993	22 PPG 39
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .687 2: .646 3: .684 4: .685	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	ReJ	JUN 0 3 1993	22 PPG 77

(Comments) NO Bumper on outer side

	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	ReJ	JUN 0 3 1993	22 PPG 77

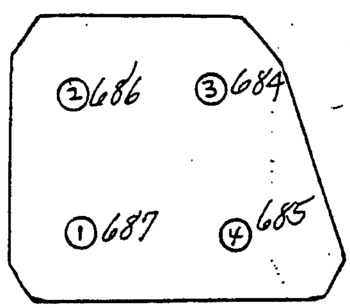
Visual Inspection Map & Comments



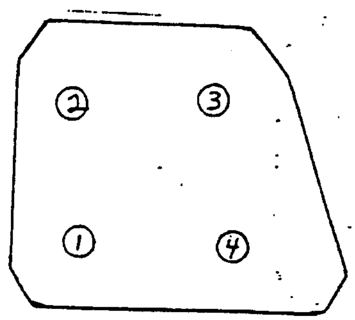
B/B Res. 123.2 ~~before~~ before T.I 96.8 after T.I

AIR ALL AROUND of UNIT And ALSO DeLam

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

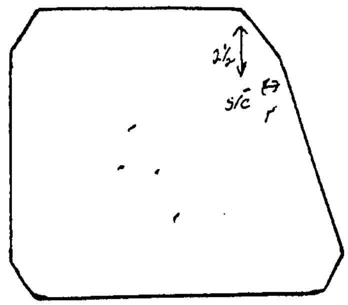
Unit Serial Number: 87-H-04-20-130

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 73.1 Ohms	Acc.	5-24-93	22 PPG 28
Thermal Image:		5-24-93	22 PPG 28
Insulation Test: (2500 VAC) Power to Metal:	Acc	MAY 26 1993	22 PPG 77
Nesa Scratch Test (81 VAC):	Acc	MAY 26 1993	22 PPG 77
Light Transmittance:	80.5	MAY 26 1993	22 PPG 77
Haze:	1.5	MAY 26 1993	22 PPG 77
Photo (Single Exposure):		26 MAY 1993	22 PPG 77
Deviation Inspection: (German Light per Template) 1: 9 2: 5 3: 7 4: 5	Acc	MAY 26 1993	22 PPG 77
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .695 2: .707 3: .712 4: .702	Acc.	5-25-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 02 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 02 1993	22 PPG 77

(Comments) wrong seal on outbd side of unit

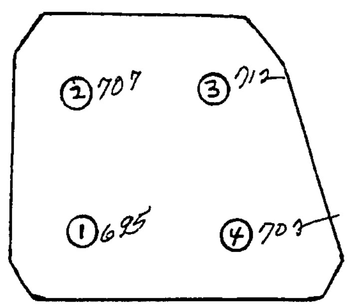
	Acc/Rej	Date	Inspector
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 02 1993	22 PPG 77

Visual Inspection Map & Comments

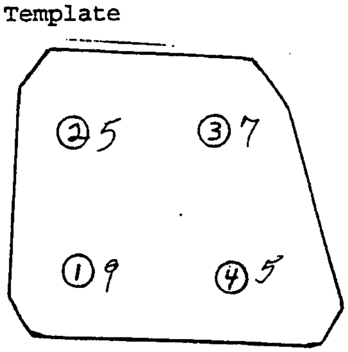


Surface chip located 2½" in down and 1" from fwd. edge
And other surface defects located center of unit

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501 Chg-H

Unit Serial Number: 8-H-2-06-585

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 29.2 Ohms		5-21-93	22 [illegible] 28
Thermal Image:		5-21-93	22 [illegible] 28
Insulation Test: (2500 VAC) Power to Metal:	ACC	MAY 2 6 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 2 6 1993	22PPG43
Light Transmittance:	82.6	MAY 2 6 1993	22PPG43
Haze:	1.1	MAY 2 6 1993	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 1 4 1993	22 PPG 8
Deviation Inspection: (German Light per Template)	Acc	6/8-93	22 PPG 40

1: <3 2: .692 <3 3: <3 4: <3

Dimensional Inspection:			
Unit Thickness: (Per Template)			

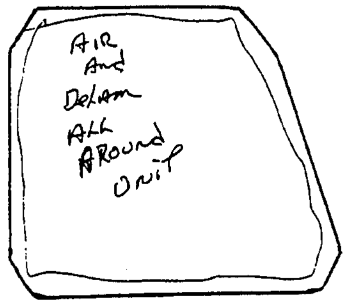
1: .692 2: .691 3: .693 4: .693

Check for Vinyl Cracks:	Acc	JUN 0 3 1993	22 PPG 77
Seal Evaluation:	Rej	JUN 0 3 1993	22 PPG 77

(Comments) wrong Seal on out bd side, Bumper is Bad on outbd side

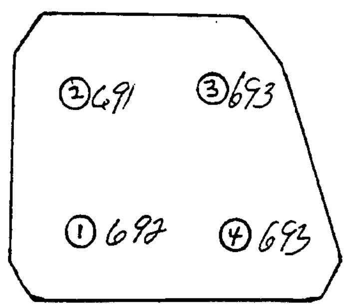
Visual Inspection: (Place comments on attached sheet)	Rej	JUN 0 3 1993	22 PPG 77

Visual Inspection Map & Comments

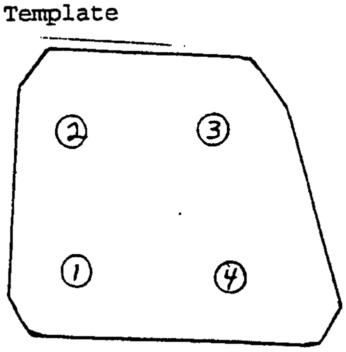


AiR And DeLAm LocATed ALL ARound UNiT

Thickness Template



Deviation Template



KC-135 Transparency Review Data Sheet
Pilot/Co-Pilot #4 Window

Customer Part Number: 5-71764-501

Unit Serial Number: 85-H-07-01-366

	Acc/Rej	Date	Inspector
Bus to Bus Resistance: 83.7 Ohms		5-21-93	22 PPG 28
Thermal Image:		5-21-93	22 PPG 28
Insulation Test: Power to Metal: (2500 VAC)	Acc	MAY 26 1993	22PPG43
Nesa Scratch Test (81 VAC):	OK	MAY 26 1993	22PPG43
Light Transmittance:	82.8	MAY 26 1993	22PPG43
Haze:	.8	~~MAY 26 1993~~	22PPG43
Photo (Single Exposure):	22 PPG 47	JUN 14 1993	22 PPG 8
Deviation Inspection: (German Light per Template) 1: <3 2: <4.5 3: <7 4: <4.5	Acc	6-8-93	[illegible]
Dimensional Inspection:			
Unit Thickness: (Per Template) 1: .699 2: .701 3: .697 4: .687	Acc	5-26-93	22 PPG 28
Check for Vinyl Cracks:	Acc	JUN 03 1993	22 PPG 77
Seal Evaluation:	Res	JUN 03 1993	22 PPG 77

(Comments) BAd Bumper at wrong Seal on out bd side

Visual Inspection: (Place comments on attached sheet)	Res	JUN 03 1993	22 PPG 77